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DOC# 58 RP
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**Work Plan
for Performing a
Remedial Investigation/
Feasibility Study**

**National Aeronautics and
Space Administration
Jet Propulsion Laboratory
Pasadena, California 91109**

ENTERED

DATE: Sep 21, 1999

F:/JPL-EAO1/SFUND/ADMINREC/FWREPORTS.XLS

EBASCO ENVIRONMENTAL

DECEMBER 1993

F I N A L

WORK PLAN FOR PERFORMING A REMEDIAL INVESTIGATION/FEASIBILITY STUDY

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY
4800 OAK GROVE DRIVE
PASADENA, CALIFORNIA 91109**

PREPARED BY

**EBASCO ENVIRONMENTAL
3000 WEST MACARTHUR BLVD.
SANTA ANA, CALIFORNIA 92704**

DECEMBER 1993

TABLE OF CONTENTS

	PAGE
1.0 EXECUTIVE SUMMARY	1-1
2.0 INTRODUCTION	2-1
2.1 FACILITY DESCRIPTION	2-1
2.2 FACILITY WASTE GENERATION AND PROCESS DESCRIPTION	2-3
3.0 WORK PLAN RATIONALE	3-1
3.1 CONCEPTUAL SITE MODEL	3-1
3.2 DESCRIPTION OF OPERABLE UNIT APPROACH	3-2
3.3 CRITERIA FOR OBTAINING ADDITIONAL DATA	3-3
3.4 DATA MANAGEMENT	3-3
3.5 REDEFINING OPERABLE UNITS	3-4
4.0 REGIONAL AND LOCAL JPL SETTING	4-1
4.1 REGIONAL JPL SETTING	4-1
4.1.1 Regional Meteorology	4-1
4.1.2 Regional Topography	4-1
4.1.3 Regional Geology	4-2
4.1.4 Regional Hydrogeology	4-3
4.1.5 Off-site Receptors Exposure Pathways	4-4
4.1.6 Potential Off-Site (Regional) Expedited Response Actions	4-6
4.2 LOCAL JPL SETTING	4-7
4.2.1 Local Meteorology	4-7
4.2.2 Local Topography	4-8
4.2.3 Local Geology	4-8
4.2.4 Local Hydrogeology	4-10
4.2.5 Areas of Concern	4-12
4.2.6 Types and Volumes of Wastes Present	4-12
4.2.7 On-site Receptors Exposure Pathways	4-14
4.2.8 Potential Expedited Response Actions	4-15
4.2.9 Preliminary Identification Of Operable Units	4-16
4.2.10 Preliminary Identification of Remedial Action Objectives and Alternatives	4-17
5.0 SYNOPSIS OF HISTORICAL WORK	5-1
5.1 PREVIOUS INVESTIGATIONS	5-1
5.1.1 Agbabian Associates (1977)	5-2
5.1.2 LeRoy Crandall and Associates (1981)	5-3
5.1.3 Geotechnical Consultants, Inc. (1982)	5-4
5.1.4 Richard C. Slade (1984)	5-5
5.1.5 James M. Montgomery (1986)	5-6
5.1.6 Ebasco Services Incorporated (1988a and 1988b)	5-7
5.1.7 Geotechnical Consultants, Inc. (1989)	5-9

TABLE OF CONTENTS

(Continued)

	PAGE
5.1.8 Ebasco Environmental (1990a)	5-10
5.1.9 Ebasco Environmental (1990b)	5-13
5.1.10 Jet Propulsion Laboratory (1990)	5-17
5.1.11 Contaminant Source Research (1990 to Present)	5-18
5.1.12 Ebasco Environmental (1991)	5-36
5.1.13 Maness Environmental Services, Inc. (1992)	5-37
5.1.14 Ebasco Environmental (1992)	5-39
5.2 PRE-RI INVESTIGATION	5-43
5.2.1 Soil Gas Survey Sampling and Analysis	5-44
5.2.2 Soil Investigation	5-45
5.2.3 Groundwater Investigation	5-48
5.2.4 Results of Laboratory Analysis	5-54
5.2.5 Periodic Groundwater Monitoring Program	5-57
6.0 JPL REMEDIAL INVESTIGATION OBJECTIVES	6-1
6.1 OPERABLE UNIT 1 RI FOR ON-SITE GROUNDWATER	6-4
6.1.1 Data Quality Objectives for OU-1	6-4
6.1.2 On-Site Groundwater Characterization	6-7
6.1.3 OU-1 Groundwater Baseline Risk Assessment	6-15
6.2 OPERABLE UNIT 2 RI FOR SOURCE CHARACTERIZATION	6-16
6.2.1 Data Quality Objectives for OU-2	6-17
6.2.2 Contaminant-Source Characterization	6-19
6.2.3 OU-2 Source Areas Baseline Risk Assessment	6-21
6.3 OPERABLE UNIT 3 RI FOR OFF-SITE GROUNDWATER	6-24
6.3.1 Data Quality Objectives for OU-3	6-24
6.3.2 Off-Site Groundwater Characterization	6-27
6.3.3 OU-3 Off-Site Groundwater Baseline Risk Assessment	6-30
7.0 JPL FEASIBILITY STUDY OBJECTIVES	7-1
7.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)	7-1
7.2 OPERABLE UNITS 1 AND 3: GROUNDWATER	7-5
7.3 OPERABLE UNIT 2: CONTAMINANT SOURCE	7-6
8.0 RI/FS TASKS	8-1
8.1 SUMMARY OF TASKS	8-1
8.1.1 Project Planning (Task 1)	8-1
8.1.2 Community Relations (Task 2)	8-2
8.1.3 Field Investigation (Task 3)	8-2
8.1.4 Sample Analysis and Validation (Task 4)	8-3
8.1.5 Data Evaluation (Task 5)	8-3
8.1.6 Risk Assessment (Task 6)	8-3
8.1.7 Treatability Study and Pilot Testing (Task 7)	8-5

TABLE OF CONTENTS (Continued)

	PAGE
8.1.8 Remedial Investigation Report (Task 8)	8-6
8.1.9 Remedial Alternatives Development and Screening of Remedial Alternatives (Task 9)	8-6
8.1.10 Detailed Analysis of Alternatives (Task 10)	8-8
8.1.11 Feasibility Study Reports (Task 11)	8-8
8.1.12 Post RI/FS Support (Task 12)	8-9
8.2 MODIFICATION OF WORK PLAN	8-9
8.3 AGENCY COORDINATION	8-10
 9.0 COST AND KEY ASSUMPTIONS	 9-1
 10.0 SCHEDULE	 10-1
 11.0 PROJECT MANAGEMENT	 11-1
 12.0 SELECTED REFERENCES	 12-1
 APPENDIX A: Soil Boring Logs	
 APPENDIX B: Boring Logs and Well Completion/Construction Diagrams for JPL Monitoring Wells	
 APPENDIX C: Geophysical Logs for JPL Monitoring Wells	

LIST OF FIGURES

<u>FIGURE NUMBER</u>		<u>FOLLOWING PAGE</u>
2-1	Site Location Map	2-2
2-2	Site Facility Map - Jet Propulsion Laboratory	2-2
3-1	Conceptual Model Illustration for the Jet Propulsion Laboratory	3-2
3-2	Conceptual Cross-Section Through the Jet Propulsion Laboratory	3-2
3-3	Conceptual Contaminant Exposure Model at the Jet Propulsion Laboratory	3-2
4-1	General Geology Surrounding the Jet Propulsion Laboratory	4-2
4-2	Areal Geology and Base of Quaternary Alluvium in the Raymond Basin	4-2
4-3	Stratigraphic Column of the Raymond Basin	4-2
4-4	Hydrologic Subbasins in the Raymond Basin	4-3
4-5	Typical Contour Maps of the Groundwater Table in the Raymond Basin	4-4
4-6	Locations of Water Spreading Grounds in Raymond Basin	4-4
4-7	Locations of Water Production Wells in Raymond Basin	4-4
4-8	City of Pasadena Municipal Water Production Wells and the Arroyo Seco Spreading Grounds Near JPL	4-8
4-9	General Location of the Principal Range-Front Faults Near JPL	4-8
4-10	Location of the JPL Thrust Fault Across JPL	4-8
4-11	JPL Fault as Mapped Behind JPL Building 150	4-8
4-12	Contour Map of Top of Crystalline Basement Complex Near JPL	4-9

LIST OF FIGURES (Continued)

FIGURE NUMBER		FOLLOWING PAGE
4-13	Summary of Field Boring Logs for Monitoring Wells MW-4 and MW-11 - Jet Propulsion Laboratory	4-9
4-14	Locations and Total Depths of Groundwater Monitoring Wells at JPL	4-10
4-15	Lines of Potential Equal Elevation of Groundwater at Various Times - Jet Propulsion Laboratory	4-10
4-16	Groundwater Elevation Versus Time for Monitoring Wells at JPL During Start-Up of City of Pasadena Groundwater Treatment Plant	4-11
4-17	Water Table Elevations in Monitoring Wells at JPL	4-11
4-18	Operable Unit Boundaries	4-16
5-1	Soil Boring and Trench Locations Referenced in Agbabian Associates (1977)	5-2
5-2	Cross-Section of Trench Across JPL Thrust Fault	5-2
5-3	Dewatering System Around Building 150	5-3
5-4	Suspected Seepage Pit Locations as Identified in the Preliminary Assessment and Site Inspection Reports	5-8
5-5	Locations of Monitoring Wells Installed and Volatile Organic Compounds Detected During the ESI of JPL	5-10
5-6	Locations of Soil Gas Collectors and Majors VOC Detections in Soil Gas	5-12
5-7	Schematic Diagram of Soil Gas Collector	5-12
5-8	Detected Volatile Organic Constituents in the Pasadena City Production Wells, November 1989	5-14
5-9	Storm Drain System at Jet Propulsion Laboratory	5-15

LIST OF FIGURES (Continued)

FIGURE NUMBER		FOLLOWING PAGE
5-10	Surface Sediment Sample Locations Completed as part of the HRS	5-15
5-11	Soil Sample Locations Completed as Part of the HRS	5-16
5-12	Aerial Photograph Looking North at JPL	5-19
5-13	Aerial Photograph Looking South at Part of JPL	5-19
5-14	Aerial Photograph Looking South at JPL	5-19
5-15	Aerial Photograph Looking West at JPL	5-20
5-16	Locations of Known Seepage Pits and Dry Wells	5-36
5-17	Boring and Sampling Locations in Building 306 Excavation	5-38
5-18	Confirmation Sampling Locations and Results	5-39
5-19	Soil Gas Sampling Locations	5-44
5-20	Locations of Groundwater Monitoring Wells at Completion of Pre-RI Investigations	5-48
5-21	Typical MP Monitoring Well Installation	5-52
6-1	Existing and Proposed Monitoring Well Location Map	6-7
6-2	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-1	6-7
6-3	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-3	6-7
6-4	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-4	6-7
6-5	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-5	6-7

LIST OF FIGURES
(Continued)

FIGURE NUMBER		FOLLOWING PAGE
6-6	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-6	6-7
6-7	Concentrations of VOCs Detected in Groundwater and Water Level Elevations, Monitoring Well MW-7	6-7
6-8	Generalized Drawing of Dual-Tube Percussion Method of Drilling	6-12
6-9	Design of Typical Shallow Groundwater Monitoring Well	6-13
6-10	Yearly Precipitation Data Near Jet Propulsion Laboratory	6-13
6-11	Design of Typical Deep Multi-Port Groundwater Monitoring Well	6-14
6-12	Proposed Operable Unit 3 Groundwater Well Locations	6-27
11-1	Summary of Project Organization	11-1

LIST OF TABLES

<u>TABLE NUMBER</u>		<u>FOLLOWING PAGE</u>
4-1	Threatened and Endangered Species Inhabiting JPL Area	4-5
4-2	Source Control, OU-2	4-17
4-3	Groundwater, OU-1 and OU-3	4-17
5-1	Summary of CCl ₄ , TCE, and PCG Concentrations in Groundwater Samples from Monitoring Well MH-01	5-4
5-2	Summary of Analytical Results for Inorganic Compounds in Groundwater Samples from Monitoring Well MH-01	5-6
5-3	Summary of Analytical Results for Organic Compounds in Groundwater Samples from Monitoring Well MH-01	5-6
5-4	Summary of Analytical Results for Groundwater Samples from Monitoring Wells MW-1 and MH-01	5-10
5-5	Summary of Construction Details for Monitoring Wells Installed at JPL During the ESI	5-11
5-6	Summary of Volatile and Semi-Volatile Organic Compounds Detected in Groundwater Samples	5-11
5-7	Summary of Metals and Total Petroleum Hydrocarbons Detected in Groundwater Samples	5-11
5-8	Relative Ranking of Volatile Organic Compounds Detected in Soil Gas Survey	5-12
5-9	Detected Volatile Organic Compounds in Groundwater Samples Collected During the June 1990 Resampling of JPL Monitoring Wells	5-14
5-10	Constituents Detected in Surface Sediment Samples Collected in the Arroyo Seco	5-15
5-11	Population Counts Within Concentric Rings Around JPL	5-16
5-12	Constituents Detected in Soil Samples Collected Adjacent to JPL	5-17

LIST OF TABLES
(Continued)

<u>TABLE NUMBER</u>		<u>FOLLOWING PAGE</u>
5-13	Summary of Detected Chemical Compounds in Soil Samples from Storm Drain Catch Basin	5-18
5-14	Personnel Interviewed at JPL	5-18
5-15	Comparison of Pit Numbers Used in Various Documents	5-19
5-16	Seepage Pit Numbers and Associated Buildings	5-20
5-17	Seepage Pit Designations and Inferred Use	5-36
5-18	Analytical Results for Contaminant Characterization, Composite Soil Sample from Building 306 Excavation	5-37
5-19	Analytical Results for Soil Test-Boring Investigation	5-38
5-20	Comparison of Program Features	5-42
5-21	Summary of Volatile Organic Compounds Detected in Soil Gas Samples	5-45
5-22	Seepage Pit Soil Sample Analyses	5-48
5-23	Construction Details for the Initial Phase RI Monitoring Wells	5-48
5-24	Summary of Organic Chemical Analyses Performed on Soil Boring Samples	5-55
5-25	Summary of Inorganic Chemical Analyses Performed on Soil Samples	5-55
5-26	Summary of Analyses Performed on Groundwater Samples Collected from JPL Monitoring Wells, December 1992 - January 1993	5-55
5-27	Summary of Volatile Organic Compounds Detected In Groundwater Samples Collected from JPL Monitoring Wells, December 1992 - January 1993	5-55

LIST OF TABLES
(Continued)

<u>TABLE NUMBER</u>		<u>FOLLOWING PAGE</u>
5-28	Summary of Title 22 Metals, Strontium, Cyanide, and Total Organic Carbon (TOC) Detected in Groundwater Samples Collected from JPL Monitoring Wells, December 1992 - January 1993	5-58
5-29	Summary of Water Chemistry Results for Groundwater Samples Collected from JPL Monitoring Wells, December 1992 - January 1993	5-58
5-30	Summary of Volatile Organic Compounds Detected in Groundwater Samples Collected from JPL Monitoring Well MW-3	5-58
5-31	Summary of Volatile Organic Compounds Detected in Groundwater Samples Collected from JPL Monitoring Well MW-4	5-58
5-32	Summary of Volatile Organic Compounds Detected in Groundwater Samples Collected from MW-5, MW-6, and MW-7	5-58
6-1	Summary of Water Level Elevations and VOCs Detected in Wells MW-8, MW-10 and MW-11	6-7
6-2	Summary of Proposed Analyses for Groundwater Samples, Soil Samples, and Samples of Soil Cuttings	6-7
6-3	Outline of OU-1 Remedial Investigation Report	6-15
6-4	Outline of OU-2 Remedial Investigation Report	6-21
6-5	OU-2 Human Receptor and Exposure Pathways On-Site Source Areas	6-23
6-6	Outline of OU-3 Remedial Investigation Report	6-30
6-7	OU-3 Human Receptor and Exposure Pathways Groundwater East of the JPL Parking Lot	6-32
7-1	Chemical-Specific ARARS at JPL	7-3
10-1	RI/FS Schedule	10-1

LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substances and Disease Registry
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CCL₄	Carbon Tetrachloride
CalEPA	California Environmental Protection Agency (In this document, the term is limited to the DTSC and the RWQCB)
CalTech	California Institute of Technology
CDHS	California Department of Health Services
CDM	Camp, Dresser, and McGee
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CI	Cast Iron
CLP	Contract Laboratory Program
CMP	Corrugated Metal Pipe
COC	Chemical of Concern
CRP	Community Relations Plan
CSF	Cancer Slope Factor
DCA	1,1-Dichloroethane
DCE	1,1-Dichloroethene
DGDMUP	Devil's Gate Dam Multi-Use Project
DNAPL	Dense Non-Aqueous Phase Liquid
DQOs	Data Quality Objectives
DTSC	Department of Toxic Substances Control
DW	Dry Well
EACCO	Environmental Affairs and Chemical Control Office
EB	Equipment Blank
EC	Specific Electrical Conductance
EPA	Environmental Protection Agency
ESI	Expanded Site Inspection
FFA	Federal Facilities Agreement
FID	Flame Ionization Detector
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan

LIST OF ACRONYMS

(Continued)

GAC	Granular Activated Carbon
GALCIT	Gugenhiem Aeronautical Laboratory, California Institute of Technology
GCI	Geotechnical Consultants, Inc.
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Tables
HRS	Hazard Ranking System
HSA	Hollow Stem Auger
ICP	Inductively Coupled Plasma
IGWMC	International Ground Water Modeling Center
IRAS	Infrared Astronomical Satellite
IRIS	Integrated Risk Information Center
JPL	Jet Propulsion Laboratory
M50	Trichloroethane
MCL	Maximum Contaminant Limit
MCLG	Maximum Contaminant Level Goal
MECL	Maximum Expected Contaminant Level
MEK	Methyl Ethyl Ketone
MES	Maness Environmental Services, Inc.
MOU	Memorandum of Understanding
MP	Multi-Port
MW	Monitoring Well
NA	Not Analyzed or Not Applicable
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
ND	Not Detected
NDQAO	NASA Designated Quality Assurance Officer
NDPM	NASA Designated Project Manager
NR	Not Regulated
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response

LIST OF ACRONYMS

(Continued)

OU-1	Operable Unit - 1
OU-2	Operable Unit - 2
OU-3	Operable Unit - 3
PA	Preliminary Assessment
PARCC	Precision, Accuracy, Representativeness, Completeness and Comparability
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene (Perchloroethene)
PE	Professional Engineer
PVC	Polyvinyl Chloride
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Risk Assessment
RAP	Remedial Action Plan
RCP	Reinforced Concrete Pipe
RCRA	Resource Conservation and Recovery Act
RFC	Reference Concentrations
RFD	Reference Dose
RG	Registered Geologist
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board, Los Angeles Region
SARA	Superfund Amendments and Reauthorization Act
SB	Soil Boring
SI	Site Inspection
STLC	Soluble Threshold Limit Concentration
SVOC	Semi-volatile Organic Compound
TB	Trip Blank
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene

LIST OF ACRONYMS
(Continued)

TCLP	Toxicity Characteristic Leachate Potential
TDS	Total Dissolved Solids
TEGD	Technical Enforcement Guidance Document
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
TTLIC	Total Threshold Limit Concentration
UR	Unit Risk
VC	Vitrified Clay
VES	Vapor Extraction System
VOCs	Volatile Organic Compounds

1.0 EXECUTIVE SUMMARY

This Work Plan is the central document in the execution of the Remedial Investigation/Feasibility Study (RI/FS) at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL is a National Aeronautics and Space Administration (NASA) owned facility managed by the California Institute of Technology (CalTech). The term "JPL" is used throughout this document to refer to the facilities located at 4800 Oak Grove Drive in Pasadena, California.

In October 1992, JPL was placed on the National Priorities List (NPL). As a NPL site, JPL is subject to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, hereafter jointly referred to as CERCLA. Pursuant to the CERCLA requirements, this RI/FS Work Plan has been developed to describe the proposed activities for characterizing the nature and extent of contamination at the JPL site and for evaluating the potential remedial options.

The soil and groundwater associated with JPL, and the groundwater pumped by nearby municipal wells have been impacted by hazardous materials. The extent and nature of this impact to the surface and subsurface environment need to be characterized and evaluated in order to select a remedy to protect human health and the environment. The RI/FS is the first step in this restoration process. Under the CERCLA guidelines, the primary purpose of the Work Plan is to present the scope of work and schedule for the RI/FS. The Remedial Investigation (RI) serves as the mechanism for collecting data to characterize site conditions, determine the nature of the waste, assess risk to human health and the environment, and conduct treatability studies if determined necessary during the investigation. The RI is performed concurrently and in an interactive fashion with the Feasibility Study (FS). The goal of the FS is to identify the remedies specific to JPL to protect human health and the environment. During the FS, potentially applicable remedial technologies are considered for the impacted media of concern and screened initially for technical feasibility. The technologies that are technically feasible are subjected to a more detailed evaluation in terms of effectiveness, technical implementability, and cost. Finally, the most promising technologies are assembled into potential alternatives for the site as a whole and evaluated in greater detail for meeting remedial action objectives.

The Jet Propulsion Laboratory began in 1936 when Professor Theodore Von Karmen of CalTech and a group of students began testing liquid propellant rockets in the Arroyo Seco. At that time the work was being completed through CalTech's Gugenhiem Aeronautical Laboratory (GALCIT). In 1940, the Army Air Corps provided funding and the first permanent structures

were built near the present day site. By 1944, the site continued to grow and changed its name to the Jet Propulsion Laboratory, GALCIT. Ultimately, the site became known as the Jet Propulsion Laboratory or JPL and became a fully owned Federal facility. In 1958, the National Aeronautics and Space Administration (NASA) took over control of JPL. Today, under a prime contract, CalTech performs research and development tasks at facilities provided by NASA that are located at the current day site of JPL. CalTech also maintains the facilities as part of its contractual agreement with NASA.

Previous investigations have given evidence that current contaminants at JPL are probably the result of waste disposal practices during the 1940s and 1950s. During that time period, many buildings at JPL maintained a seepage pit or cesspool for disposing liquid and solid wastes. Since many buildings used or stored hazardous chemicals, it is believed that the seepage pits may have received various quantities of these chemicals. The pits were abandoned in the late 1950s and early 1960s, but may still act as contaminant sources. Today, NASA maintains strict adherence to applicable State and Federal Hazardous-waste regulations. Under California State law (California Code of Regulations, Title 22, Chapters 11 and 12) the site qualifies as a generator and complies with the regulations governing this designation.

The JPL facility is located at the northern edge of the metropolitan Los Angeles area. It is comprised of approximately 176 acres of which 156 acres are Federally owned. The remaining 20 acres lie in two cities; Pasadena and La Canada-Flintridge. It is bounded by the San Gabriel mountains to the north, the Arroyo Seco wash to the east and an equestrian club to the southwest. Also to the south lies the Devils Gate Reservoir.

JPL is situated on a relatively steep alluvial slope at the southern edge of the San Gabriel Mountains and at the northern edge of the San Gabriel Valley. A series of east-west trending and north dipping thrust faults referred to as the Sierra Madre Fault system separate the mountains from the valley. Beneath JPL the alluvial plain deposits range in thickness from 650 to 850 feet. The alluvial deposits rest on a crystalline basement complex made up of the same general rock types as those comprising the San Gabriel Mountains. The vadose zone ranges between 100 to 250 feet in thickness and the saturated alluvium forms a water-table aquifer ranging between 550 and 600 feet in thickness. JPL is situated in the Monk Hill Subbasin of the larger Raymond Basin.

The Raymond Basin is a distinct groundwater basin in the San Gabriel Valley and is bordered on the north by the San Gabriel Mountains, on the west by the San Rafael Hills and on the South by the Raymond Fault. The Raymond Basin is an important source of groundwater for local communities. Users of the groundwater supply nearest to JPL include La Canada-Flintridge,

Pasadena, and Altadena. A number of municipalities, purveyors, and users have specific rights to the groundwater resource as the basin is under adjudication. Presently, use of the groundwater resource is governed by the Raymond Basin Water Board. In addition the basin is being considered as a natural subsurface reservoir for groundwater storage.

The regional groundwater flow gradient is generally from JPL toward the southeast. Along the border of JPL is located the Arroyo Seco spreading basins. To the east of the Arroyo Seco, the City of Pasadena has municipal water supply wells. Constant changes in these sources and sinks and meteorological factors can cause the gradient to shift radically. Municipal water supply wells, considered downgradient, have been impacted by similar wastes as those used at JPL. Previous investigations, monitoring, and screening have identified volatile organic compounds (VOCs) as the primary constituents of interest in the soil and groundwater.

A preliminary assessment of the JPL site and its vicinity has identified potential human and ecological receptors and exposure pathways for VOC-impacted soil and groundwater. Accordingly, the most likely off-site exposure medium was determined to be through public supply wells downgradient of JPL. NASA has funded the installation and operation of a groundwater treatment system for four City of Pasadena production wells. The treatment effectively eliminates the contaminants from the water, thereby eliminating public exposure through water from the Pasadena city wells. The plant is operated concurrent with operation of these four wells. Similar water quality problems have been shown in two Altadena water supply wells. The Lincoln Avenue Water Company has installed a groundwater treatment system for these wells.

The contaminants associated with JPL may potentially endanger sensitive species through the Arroyo Seco and the Devils Gate Dam reservoir area. Four endangered and two threatened species of flora and fauna have been identified for the reservoir rehabilitation and habitat project. During the RI/FS, additional efforts will be made to identify any other sensitive species that may be impacted by the JPL site remedial activities. All endangered species identified will be considered in the ecological risk assessment of the JPL site.

For purposes of the RI/FS, the JPL site has been divided into three operable units proposed by NASA and agreed upon by the United States Environmental Protection Agency Region 9 (EPA), the California State Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board (RWQCB). Operable Unit 1 (OU-1) is the on-site groundwater characterization operable unit. Operable Unit 2 (OU-2) pertains to the on-site contaminant source characterization, and Operable Unit 3 (OU-3) refers to the off-site groundwater characterization. The operable units were assigned to focus the level of efforts in

the critical areas and also because certain areas of the JPL site are at different stages of investigation and remediation.

Progress and completion of the RI/FS will be governed by EPA's Office of Solid Waste and Emergency Response Directive 9355.0-7B, "Data Quality Objectives for Remedial Response Activities: Development Process". Developing data quality objectives (DQOs) is a three-stage iterative process of scoping and identifying data needs, data collection and reevaluation, and final data collection program. This DQO process will control the data collection and evaluation activities throughout the RI/FS process at JPL. Each operable unit for JPL will have a separate RI/FS document although each operable unit's results may be used to support the results from the other two.

During the RI/FS program, data on constituents of interest will be collected and reported under EPA Level IV guidelines. For the initial sampling event for each operable unit, and on 10 percent of the results collected subsequently, the Level IV data packages will be validated as a check on laboratory performance. The 10 percent of the sample results subsequently collected during the RI that will be validated will include results with both high and low concentrations.

Preliminary identification of remedial action objectives and alternatives for OU-1 and OU-3 groundwater migration control and for OU-2 contaminant source control has been completed during scoping of the RI/FS. As additional data become available during the RI, the remedial action objectives will be modified as necessary. Both the OU-1 RI for on-site groundwater and OU-3 RI for off-site groundwater will focus on further defining the nature and extent of the contamination and understanding the dynamics of the groundwater flow system. For OU-1, five new wells, MW-12 through MW-16, will be constructed. Three of these wells will be shallow standpipe wells and two will be deep multi-port wells. The wells will be strategically placed to collect water quality data that will allow determining the horizontal and vertical extent of contamination and providing groundwater elevation data.

The OU-2 RI field program will encompass activities to characterize on-site sources. Known and suspected source areas will be screened by the use of shallow soil vapor surveys. Soil borings will be drilled for direct sampling of identified source areas to determine vertical distribution of contaminants in soil. Some borings will be completed as soil vapor wells for long-term monitoring. Results of an initial shallow soil gas survey showed sample analyses results up to 8,000 micrograms/liter ($\mu\text{g/l}$) of carbon tetrachloride. Particular areas of exploration include the numerous seepage pits and the previously excavated east gate storm drain catch basin.

OU-3 is the off-site groundwater beyond the Arroyo Seco to the east and also groundwater south of JPL. Five deep multi-port wells, MW-17 through MW-21, are proposed for the OU-3 characterization. Four of the wells, MW-17 through MW-20, are spread over the area east of the Arroyo Seco to monitor and define the extent of the contaminant plume and to assess the hydrogeologic impacts of the municipal supply well pumping and recharge in Arroyo Seco. The fifth deep well, MW-21, will be located 2,000 feet southwest of JPL and will serve as a background monitoring well for all constituents of interest.

The characterization field programs and laboratory support for each operable unit will be performed according to procedures described in detail in the JPL RI/FS Field Sampling and Analysis Plans (FSAPs) prepared for each unit and in the Quality Assurance Project Plan (QAPP). Each of these plans incorporate applicable State and Federal procedures.

The FS will be based on the results of the RI activities and will include the consideration and evaluation of numerous alternatives to remediate contamination. The FS process consists of several phases for identifying the potential remedial technologies and screening/development of the remedial alternatives. The FS will consider the results of the treatability studies and the Applicable or Relevant and Appropriate Requirements (ARARs). Nine evaluation criteria have been developed to address CERCLA requirements and statutory considerations and to address the additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria are the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and performance
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State (support agency) acceptance
- Community acceptance

Under EPA guidelines, a remedy is considered protective if it adequately eliminates, reduces, or controls all current and potential risks associated with each exposure pathway at the site. In accomplishing this, a given remediation alternative must meet or exceed ARARs. For JPL, chemical-specific ARARs and the risk assessment will be used to identify requirements that must be met as a minimum by a selected remedial alternative and to provide a basis for establishing

appropriate cleanup levels. Action-specific ARARs will be considered when specific remedial alternatives are evaluated for implementation. Finally, the combined consideration of location-specific ARARs, chemical-specific ARARs and action-specific ARARs are used to ensure that remedial actions are protective of human health and the environment by meeting the requirements of all ARARs.

To complete the RI/FS at the JPL, 12 tasks have been identified. These tasks are:

- Task 1 - Project Planning
- Task 2 - Community Relations
- Task 3 - Field Investigation
- Task 4 - Sample Analysis and Validation
- Task 5 - Data Evaluation
- Task 6 - Risk Assessment
- Task 7 - Treatability Study and Pilot Testing
- Task 8 - Remedial Investigation Reports
- Task 9 - Remedial Alternatives Development/Screening
- Task 10 - Detailed Analysis of Alternatives
- Task 11 - Feasibility Study Reports
- Task 12 - Post RI/FS Support

These tasks are briefly described in this Work Plan. It is expected that modifications will be made to the Work Plan through the Data Quality Objectives process. Final modifications will be a joint decision process of EPA, DTSC, RWQCB, and NASA.

The Work Plan also presents key assumptions in arriving at a cost estimate of \$7,700,000 to complete all activities through the Record of Decision (ROD).

A projected project schedule shows completion of the RI/FS and ROD's for each of the three operable units by May 1996.

2.0 INTRODUCTION

The purpose of this work plan is to present the scope of work as well as an estimated level of effort and schedule for the Remedial Investigation/Feasibility Study (RI/FS) at the National Aeronautics and Space Administration's Jet Propulsion Laboratory (JPL). The term "JPL" is used throughout this document to refer to the facilities located at 4800 Oak Grove Drive in Pasadena, California.

The primary objective of the Remedial Investigation (RI) is to identify and characterize on-site contaminant sources, identify the nature of contaminant migration pathways, evaluate the lateral and vertical extent of contaminants in the on-site and off-site groundwater, and identify the risk to actual and potential receptors. The RI will include the collection of field data and the incorporation of existing data to define the nature and extent of contaminant migration.

Following the completion of the RI, the data collected will be evaluated as part of a Risk Assessment (RA) for potential receptors. The purpose of this effort will be to quantify risks posed by contaminants in groundwater and source areas and set forth criteria which can be used to evaluate remedial alternatives as part of the Feasibility Study (FS).

The primary objective of the FS is to utilize the information collected during the RI site characterization and the RA to identify potentially applicable remedial technologies for the media of concern and to formulate these technologies into a cost-effective remedial action or set of remedial actions. These technologies are intended to permanently prevent or minimize the release of hazardous substances that may cause environmental contamination and risk to present or future public health. This objective will be accomplished through the identification, screening, testing, and evaluation of remedial alternatives based on the overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and performance; reduction of toxicity, mobility, or volume; implementability; cost; state (support agency) acceptance; and community acceptance.

2.1 FACILITY DESCRIPTION

JPL is located in the foothills of the San Gabriel Mountains at the northern edge of the metropolitan Los Angeles area. The site is Federally owned land that lies partly in two cities, northwestern Pasadena and southeastern La Canada-Flintridge. The site is bounded by a ridgeline of the San Gabriel Mountains to the north, the Arroyo Seco wash to the east, and an equestrian club (Flintridge Riding Club) and a Los Angeles County Fire Department Station to

the southwest. Further south lies a U.S. Forest Service Ranger Station, La Canada High School, Oak Grove County Park, and Devils Gate Dam. A residential neighborhood of La Canada-Flintridge borders JPL on the west. The location of JPL within the local surrounding area is illustrated in Figure 2-1.

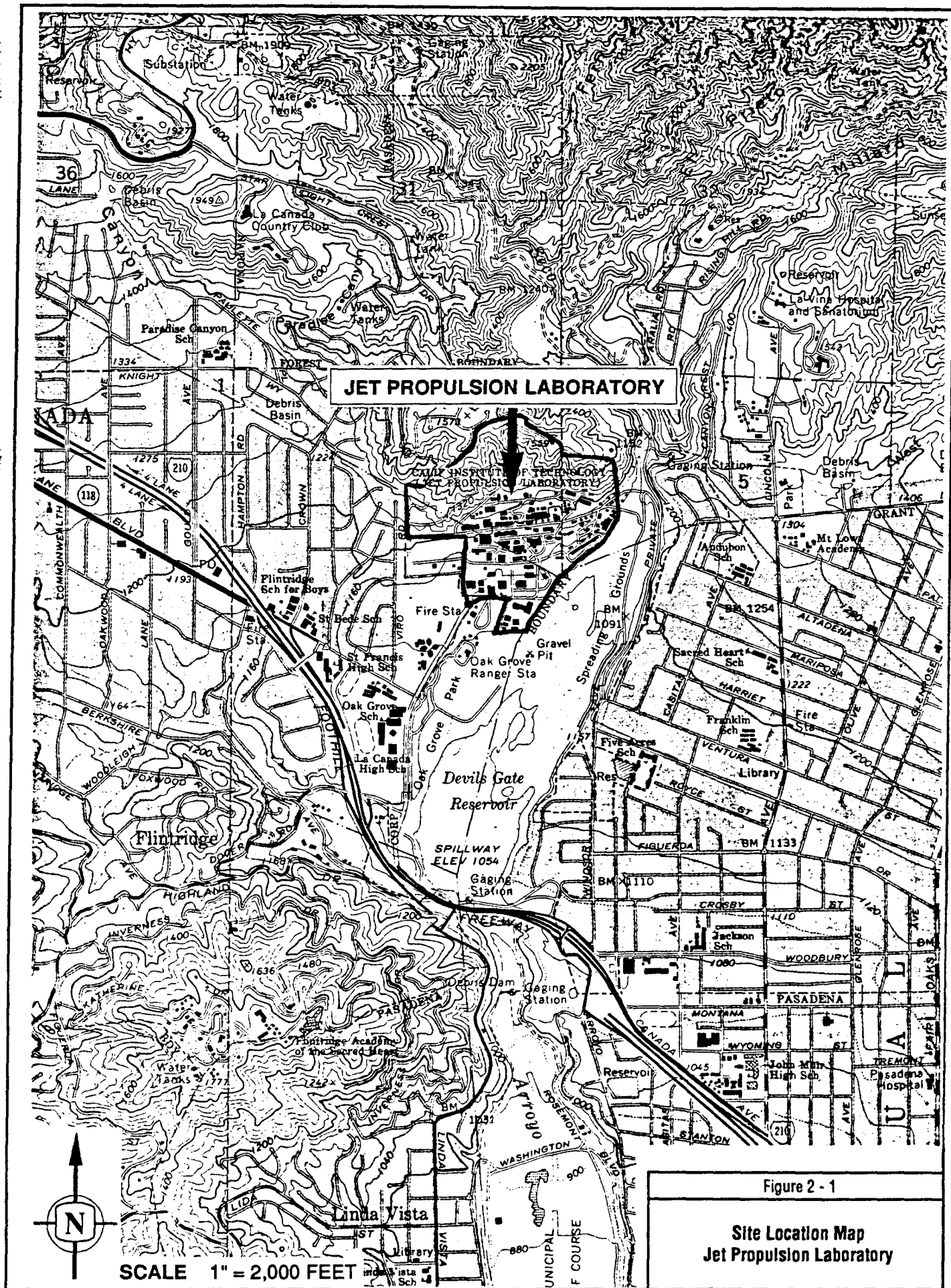
The Jet Propulsion Laboratory began in 1936 when Professor Theodore Von Karmen of the California Institute of Technology (CalTech) and a group of students began testing liquid propellant rockets in the Arroyo Seco. At that time the work was being completed through CalTech's Gugenhiem Aeronautical Laboratory (GALCIT). In 1940, the Army Air Corps provided funding and the first permanent structures were built near the present day site. By 1944, the site continued to grow and changed its name to the Jet Propulsion Laboratory, GALCIT. Ultimately, the site became known as the Jet Propulsion Laboratory or JPL and became a fully owned federal facility. In 1958, the National Aeronautics and Space Administration (NASA) took over control of JPL. Today, under a prime contract, CalTech performs research and development tasks at facilities provided by NASA and which are located at the current day site of JPL. CalTech also maintains the facilities as part of its contractual agreement with NASA.

Today, the JPL site is comprised of approximately 176 acres (Figure 2-2). Of this, approximately 156 acres are Federally owned, with the remaining land leased from the City of Pasadena and the Flintridge Riding Club for parking. The main developed area is located on the southern half of the site, and is comprised of two major areas, the northeastern early-developed area and the southwestern later-developed area.

Currently, the northeastern sector is used for project support, testing, and storage facilities, while the southwestern area houses most of the personnel, administrative, management, laboratory, and project functions of JPL. Further expansion of the main developed area is constrained because of steeply sloping terrain, the Arroyo Seco wash to the east and residential development to the west.

Located at the northern boundary of JPL, is the Gould Mesa area. This area has widely separated, small one- and two-story buildings and is used primarily for antenna testing. The distance between buildings is a result of the terrain and the need to isolate transmitting and receiving equipment.

The mountainside area is sparsely developed and unpopulated. It is accessible to authorized personnel only. The only improvements to this area are water storage tanks and Mesa Road. Future development in this area is constrained by topographic considerations.



JET PROPULSION LABORATORY CALIFORNIA INSTITUTE OF TECHNOLOGY SITE PLAN - FACILITY LOCATIONS

Facility Locations

No.	Facility Title	Location	No.	Facility Title	Location
11	Space Sciences Laboratory	4-F	220	NCS Terminal	4-D
18	Structural Test Laboratory	5-D	224	Sewage Lift Station	8-C
67	Material Research	5-C	225	Nitrogen Facility Office	5-D
72	Engineering Office	5-D	228	Solvent Storage	5-D
78	Hydraulics Laboratory	5-D	227	Field Range Storage	3-B
79	Wind Tunnel (20 inch)	4-D	228	Cooling Tower (A-B)	4-B
82	High Vacuum Laboratory	5-D	228	Shaded Room Building	5-D
83	Quality Assurance	5-D	230	Space Flight Observation Facility	5-C
84	Chemical Materials Laboratory	5-E	231	Paint Shop	8-C
86	Solid Outdoor Laboratory	5-C	232	System Development	5-C
87	Propellant Conditioning Laboratory	4-E	234	Lumber Storage	8-C
88	Welding Laboratory	4-E	237	Cooling Tower	4-E
89	Linear Laboratory	5-E	238	Telecommunications	5-C
90	Pyrotechnics Laboratory	4-E	238	Propellant Conditioning Laboratory	4-E
91	Air Dryer	5-D	241	Receiving and Shipping	7-C
97	Development Laboratory and Office	4-E	243	Remote Antenna Range Control	2-C
98	Solid Fuel Laboratory	5-D	244	Chemical Engineering	4-E
103	Fabrication Shop	5-C	245	Spectroscopy Laboratory	4-B
107	Laser Research Laboratory	4-F	248	Solar Test Laboratory	4-D
111	Technical Information	5-C	248	10-Foot Space Simulator	6-B
113	Pneumatics Laboratory	5-E	249	Yellow Reception	4-E
116	Electronics Development	5-D	250	Main Guard Shelter	6-B
118	Propellant Storage Dock	4-F	251	Cry Laboratory	4-E
117	Liquid and Solid Propellant Laboratory	5-D	252	Guard Shelter	6-B
121	Analytical Instruments Laboratory	4-F	253	Magnetic Laboratory	4-E
122	Energy Conservation Systems	5-B	255	Sewage Lift Station	7-C
125	Combined Engineering Support	5-D	255	Model Range Control	2-C
126	Information Systems Development	5-E	257	Main Guard Island	6-B
129	Combustion Research Laboratory	5-C	258	Water Reservoir	3-F
138	Mission Operations	5-E	259	Liquid Nitrogen Bunting Storage	5-D
140	Propulsion Materials Storage	4-D	260	Burninator Equipment	3-B
141	Propulsion Materials Storage	4-D	261	Controlled Storage	6-D
143	Solid Rocket Dock	4-E	262	Radiometer	2-B
144	Environmental Laboratory	4-E	263	First Aid	6-D
145	Negative - Propellant	4-E	264	Space Flight Support	3-C
148	Energy Conservation Laboratory	4-D	267	Water Reservoir	7-C
149	Energy Conservation Development	4-E	268	Pump House	3-C
150	25-Foot Space Simulator	5-C	270	Sewage Metering Station	7-B
156	Applied Mechanics	6-D	271	Oil Storage	6-D
158	Material Research Processing Laboratory	6-D	272	East Humidor	3-D
159	Pump House (water)	4-F	273	Antenna Tower	5-D
160	Pump House (sewage)	6-D	275	Pyrotechnic Storage	4-E
161	Telecommunications Laboratory	5-C	276	Propellant Storage	5-E
166	Cooling Tower	5-C	277	Isotope Thermoelectric Sys Appl Lab	5-E
167	Cafeteria	7-C	278	Robotics Laboratory	6-D
168	Instrument System Laboratory	7-C	279	Guard Island	7-C
169	Earth Space Science	7-D	280	Static Test Tower	4-D
170	Fabrication Shop	7-D	281	Fire and Guard Headquarters	6-D
171	Material Services	7-D	283	Isolator Storage	6-D
173	Test Shelter	4-F	284	Transportation Office	5-E
175	Water Reservoir	4-F	285	Access Bridge	4-C
177	Transportation Garage	5-E	286	Guard Shelter	4-F
178	Spacecraft Assembly Facility	3-E	287	Guard Island	4-F
180	Administration	6-B	288	Project Equipment Storage	4-D
183	Physical Science Laboratory	6-B	288	Main Sewage Lift Station	5-D
184	Electronic Stores	6-D	289	Antenna Inspection	7-D
185	Programming Office	5-C	291	Procurement Services	8-C
186	Science Exhibits and Engineering	6-E	292	Fire Station	6-D
187	Chemical Storage	6-E	293	Instrumentation Cable Amplifier Building	6-C
189	Electronics Laboratory Annex	5-D	294	Guard Shelter (Water Lot)	6-B
190	Procurement Office	5-D	295	Antenna Test Facility	5-E
191	Materials Compatibility Laboratory	6-C	296	Central Cooling Tower Water System	5-D
195	Guard Shelter	7-C	297	Range Test Laboratory	4-E
196	Guard Shelter	5-B	298	Frequency Standard Laboratory	4-F
197	Solid Propellant Engineering Laboratory	4-E	299	Assembly Handling & Shop Equip. Fac.	4-D
198	Control Systems Laboratory	6-D	300	Earth and Space Science Laboratory	6-E
199	Catapult Simulator	6-D	301	Control Engineering Building	6-C
200	Facilities Engineering and Services	6-D	302	Microdevices Laboratory	6-E
201	Computer Shop	6-C	303	Engineering Support Building	5-E
202	Procurement and Communications Support	6-C	304	Disintegrator	6-D
212	Antenna Laboratory	7-C	305	Hazardous Waste/Dropship Storage Facility	7-C
218	Credit Union	7-C	306	Observational Instruments Laboratory	7-C

MODULARS
 1701-1712 Modular Offices 4-D

Figure 2 - 2

**Site Facility Map
 Jet Propulsion Laboratory**

Presently, over 150 structures and buildings occupy the JPL site. Total usable building space is approximately 1,330,000 square feet, of which about 40,164 square feet is occupied by trailers and vans. Building locations within the facility are illustrated in Figure 2-2.

The northern half of the site is mountainous while the southern half of the site is moderately sloping and has been extensively graded. Elevation varies from 1,075 feet to 1,550 feet above mean sea level. Surface runoff on JPL is generally from north to south. Surface water from the mountains to the north is collected and transmitted by an underground storm-drain system through the developed southern portion of the site and is then discharged into the Arroyo Seco. The storm-drain system, designed to control runoff from a calculated maximum rainstorm within a 50-year period, includes four major drains (24 to 48 inches in diameter) that extend from the northern slopes and terminate at the Arroyo Seco. Branch lines (12 to 24 inches in diameter) collect local surface drainage and divert the water to the major drains. The storm drain system has been modified and expanded throughout the years as the site has been modified and expanded throughout the years. Runoff from parts of La Canada-Flintridge join the JPL storm drain system at the western edge of JPL just north of the main entrance (Building 249) before being discharged to the Arroyo. A layout of the existing storm drain system is presented in Section 5.1.9.

2.2 FACILITY WASTE GENERATION AND PROCESS DESCRIPTION

To accomplish the wide variety of tasks involved with space exploration, aeronautical development, and technological development, a wide variety of support functions and research and development laboratories using various chemicals and generating different types of waste have been, and are currently present at JPL. After reviewing the current waste-handling procedures used at JPL along with reports of previous investigations and interviews with former and current JPL employees, it appeared that the current contaminants at JPL may be the result of waste disposal practices used during the 1940s and 1950s.

During the 1940s and 1950s, many buildings (approximately 40) at JPL maintained a seepage pit (cesspool) to dispose of liquid and solid wastes through drains and sinks within that building. These seepage pits were designed to allow liquid wastes to seep into the surrounding soil. Since nearly every building at JPL at one time either used or stored various quantities of hazardous chemicals, it is believed that the seepage pits may have received various quantities of chemicals used at the facility. Although the seepage pits have been abandoned since the late 1950s and early 1960s when a sewer system was installed, a number of these abandoned seepage pits may be possible sources of contamination.

Unfortunately, records of waste-generating and waste-disposal procedures at JPL during the 1940s and 1950s are not available. However, the current waste-disposal procedures are known. Below is a summary of the waste-handling procedures currently being conducted at JPL.

Non-hazardous wastes such as garbage and trash (solid waste) generated on the JPL site are collected in containers and barrels dispersed throughout the site and are disposed of daily by a disposal contractor. About once every 2 weeks, a large construction materials container is also removed. Certain non-hazardous used materials such as scrap metal, metal drums, scrap paper, and precious metals are recovered and recycled.

Hazardous wastes are controlled and managed under the direction of JPL's Environmental Affairs and Chemical Control Office (EACCO). Hazardous wastes accumulated for disposal are moved by the EACCO to the hazardous waste accumulation facility (Building 305) on the JPL site. No waste is accepted for storage unless it is properly contained and identified by a Hazardous Waste Disposal Form which provides chemical name, associated hazards, quantity, physical state, and other specific information. Decisions about whether a particular waste is hazardous or non-hazardous are made by the EACCO in accordance with applicable state and Federal hazardous-waste regulations. This system is designed to maintain a complete and precise waste inventory. JPL staff are trained to provide an updated inventory of hazardous materials to emergency response authorities in case of emergencies. A 24-hour-per-day fire department is maintained on the JPL site. The fire department is equipped to handle hazardous materials or waste incidents that occur on the laboratory.

Stored wastes are removed from the hazardous waste facility at the site by a licensed hazardous waste hauler to permitted hazardous waste disposal or recycling facilities. No waste is kept in the hazardous waste accumulation facility for more than 90 days. Certain drummed waste oils and solvents are removed by a waste oil and solvent recycling company. All solvents and waste oils are recycled off the site for reuse. Extremely incompatible hazardous wastes are lab-packed in vermiculite in drums. Explosive materials are stored in a military-type ammunition bunker elsewhere on the JPL site.

Because of the varied nature of the research and development at JPL, numerous different types of hazardous laboratory chemical wastes are also generated. Generally, the laboratory wastes are generated in small quantities and are commonly chemicals that have exceeded their shelf life. An inventory of hazardous chemical wastes in storage for disposal at a given time may include over 100 different substances. In most cases, the quantities of these substances are laboratory quantities; that is, less than a gallon of liquid or kilogram of solid material.

JPL's possession and use of radioactive materials are licensed by the State of California and the United States Government. A Radiation Safety Committee, composed of staff members experienced in the handling and safeguarding of radiation sources and radioactive materials, administers JPL's responsibilities under these licenses. The committee authorizes uses, prepares hazard analyses, establishes safety practices, approves facilities in which radiation sources will be used, and generally supervises and monitors all activities in which radiation hazards may be a factor. A Radiation Safety Officer, appointed by the Laboratory Director, supervises and directs the NASA Designated Safety Office in performing day-to-day duties as they pertain to radiation safety. All ionizing-radiation sources of specified activities are licensed or registered. Possession and operation of ionizing-radiation sources involves stringent controls and procedures. Nearly all radioactive materials at JPL are sealed sources used to develop and calibrate low-level instruments. A licensed contractor removes radioactive waste to an authorized disposal site.

Because of the quantities of hazardous wastes generated by JPL, the facility is classified as a generator under the California Code of Regulations, Title 22, Chapters 11 and 12. A generator of hazardous waste accumulates 1,000 kilograms or more of hazardous waste per month. In compliance with hazardous waste laws for generators, JPL has prepared a contingency plan, preparedness and prevention plan, and provides training to employees who handle hazardous waste. The hazardous-waste inventory is updated and inspected weekly in the hazardous waste accumulation facility.

3.0 WORK PLAN RATIONALE

The RI/FS Work Plan has been developed based on a variety of conditions and assumptions developed as a result of existing geologic and hydrogeologic data and a conceptual model of contaminant transport described below. The movement of contaminants from JPL is a function of their chemical form and the interaction of contaminants with the meteorological, geological, and hydrogeological aspects of the site. This work plan includes separate discussions of field investigation efforts for each of three operable units, yet it is anticipated that there will be a large degree of technical interaction linking the transport of contaminants in the vadose zone to the underlying groundwater and the linkage of the on-site and off-site groundwater flow.

3.1 CONCEPTUAL SITE MODEL

JPL is situated on a relatively steep slope at the southern edge of the San Gabriel Mountains and at the northern edge of the San Gabriel Valley. A series of east-west trending and north-dipping thrust faults referred to as the Sierra Madre Fault system separate the San Gabriel Mountains from the San Gabriel Valley. Beneath JPL there are between 650 feet and 850 feet of alluvial-plain deposits. These materials are coarse clastic materials from the San Gabriel Mountains resting on a crystalline basement complex made up of the same general rock types as those comprising the San Gabriel Mountains (diorites, granodiorites, granites, etc.). The vadose zone beneath JPL ranges between 100 feet and 250 feet in thickness. The aquifer beneath JPL ranges between 550 feet and 600 feet in thickness. For more details on the regional and local geology and hydrogeology of JPL see Sections 4.1 and 4.2

After reviewing reports from previous investigations and interviews with former and current employees at the JPL facility, there was evidence that the waste-disposal practices used during the 1940s and 1950s may be the cause of the contamination currently identified on the site. Before the present sewer system was installed at JPL in the early 1960s, seepage pits (cesspools) were used to dispose of liquid and solid wastes. Many of these seepage pits are believed to have received various quantities of chemicals used at the site. A list of constituents of interest based on the information obtained during previous investigations is included in Table 7-1. In addition to the seepage pits, other contaminant sources may have been present. During construction and excavation activities at JPL in November 1990, the volatile organic compounds (VOCs) listed in Table 5.13 (Section 5.1.10) were detected in sediments contained by a storm drain catch basin. In addition, it was reported that approximately three 55-gallon drums containing various concentrations of solvents were dumped southeast of Building 248 in three holes measuring about 4 feet across and 3 feet deep every 3 to 4 months for 2 or 3 years in the late 1950s (see Section 5.1.11). Also during this time period, a large shallow depression was bulldozed in the Arroyo for disposing of solid

wastes (Figure 5-12, Section 5.1.11). It was reported that liquid wastes may have been intermittently dumped in an erosion channel near Building 103 (see Sections 5.1.6, 5.1.9, and 5.1.11). Most recently, in 1991 while excavating for Building 306's foundation, approximately 19,000 tons of soil contaminated with petroleum hydrocarbons from unknown sources were encountered, excavated and properly disposed in Class II and Class III landfills (Section 5.1.13).

A conceptual model and conceptual cross-section of the JPL site are included as Figures 3-1 and 3-2, respectively. The conceptual model shows the relationships between the potential source areas and the surrounding environment. The conceptual cross-section depicts idealized contaminant migration pathways from the source areas as being primarily through infiltration or percolation into and through the vadose zone to the groundwater. In the case of the November 1990 excavation around a storm drain catch basin, air and surface water became potential migration pathways. Migration through these pathways would have been minor due to the volume of soil affected and the limited time of exposure.

Potential source areas, release mechanisms, contaminant pathways, and potential receptors identified in the conceptual contaminant exposure model are summarized in Figure 3-3. Known and suspected source areas of hazardous materials at JPL have generally involved a surface impoundment such as seepage pits, dry wells, temporary pits and various drains, basins and excavations. Fluid contaminants in these surface impoundments may have infiltrated into the subsurface impacting the soil. Both the source areas and impacted soil are contaminant sources that may endanger potential receptors by being carried through air, groundwater, or surface water pathways. The major potential human receptors of contaminants from JPL include area residents and site visitors who drink untreated contaminated groundwater. When source areas are excavated, potential secondary pathways to human and biota receptors, including air (volatilization of contaminants) and surface water are also present on the site (Figure 3-3).

3.2 DESCRIPTION OF OPERABLE UNIT APPROACH

The JPL site has been divided into three operable units (see Figure 4-18, Section 4.2.9). Operable Unit 1 (OU-1) pertains to the on-site groundwater characterization, Operable Unit 2 (OU-2) is the on-site contaminant-source characterization, and Operable Unit 3 (OU-3) refers to the off-site groundwater characterization. The operable units were assigned to focus the level of efforts in the critical areas and also because certain areas of the JPL site are at different stages of investigation and remediation.

This approach may differ from other similar RI/FS studies because preliminary groundwater studies conducted to date have shown certain on-site areas to be potential source areas, yet historic documentation of the potential source area and pilot characterization studies of the those

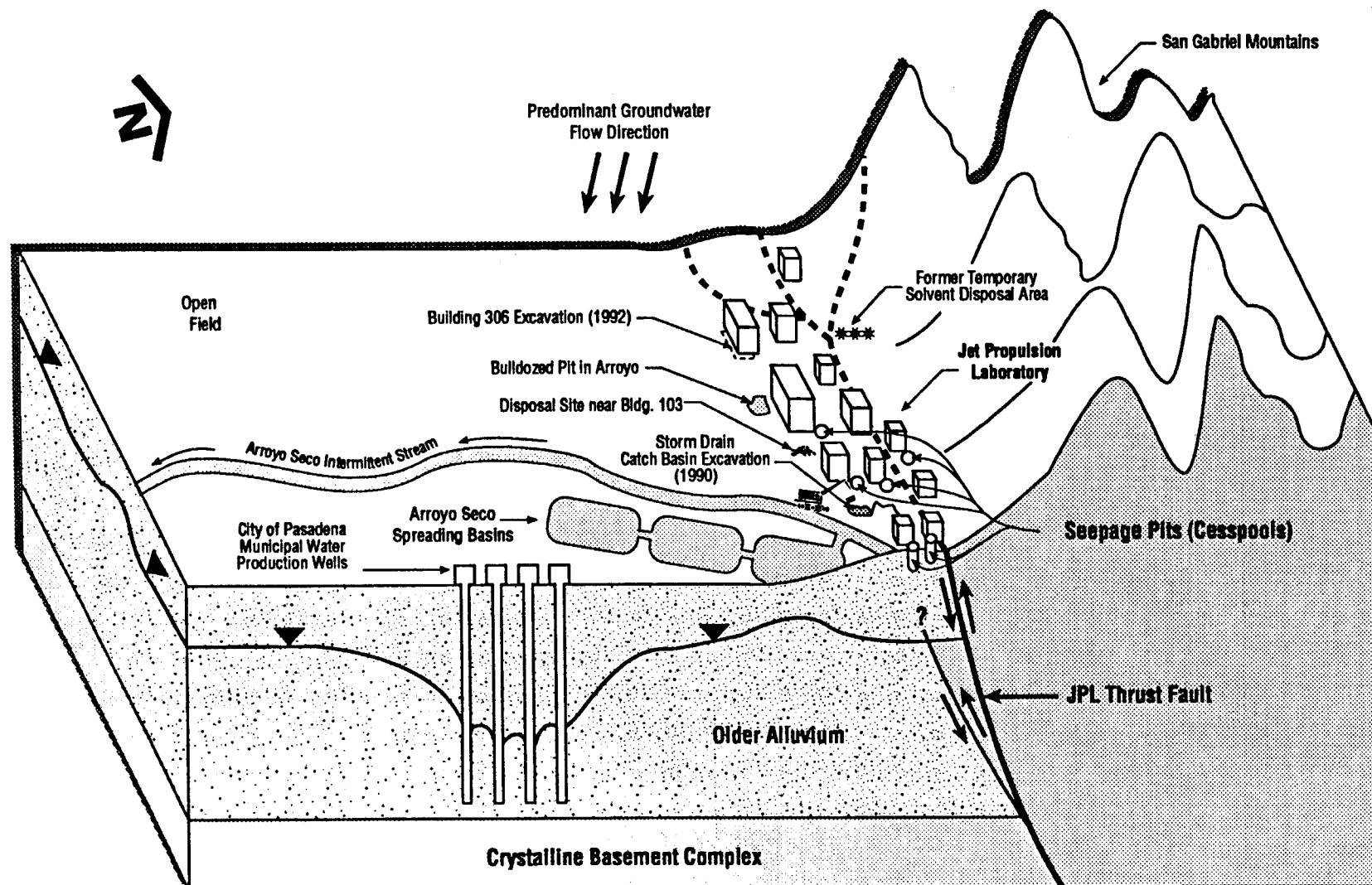


Figure 3 - 1

Conceptual Model Illustration
for the Jet Propulsion Laboratory

POTENTIAL SOURCES

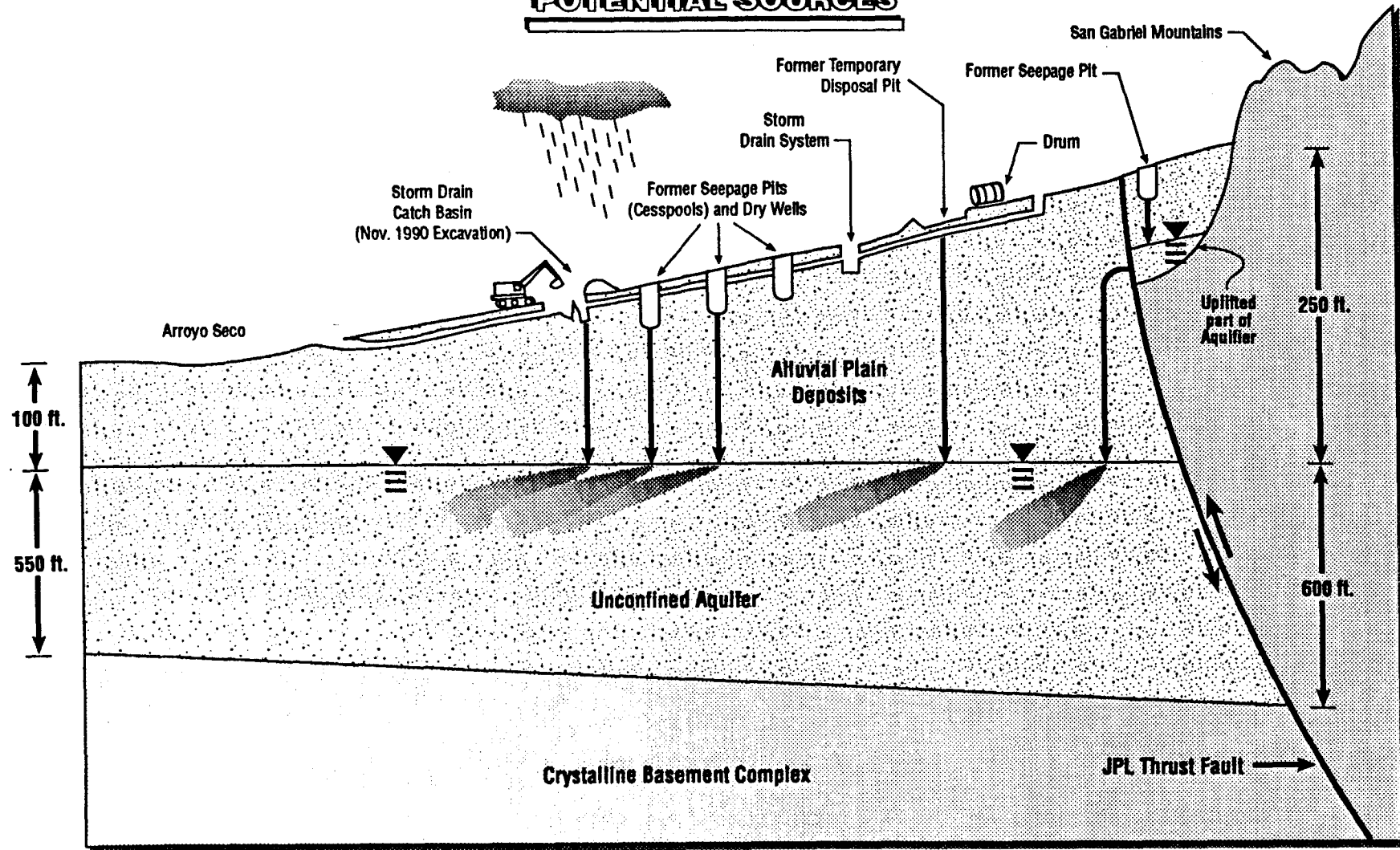


Figure 3 - 2

Conceptual Cross-Section Through
the Jet Propulsion Laboratory

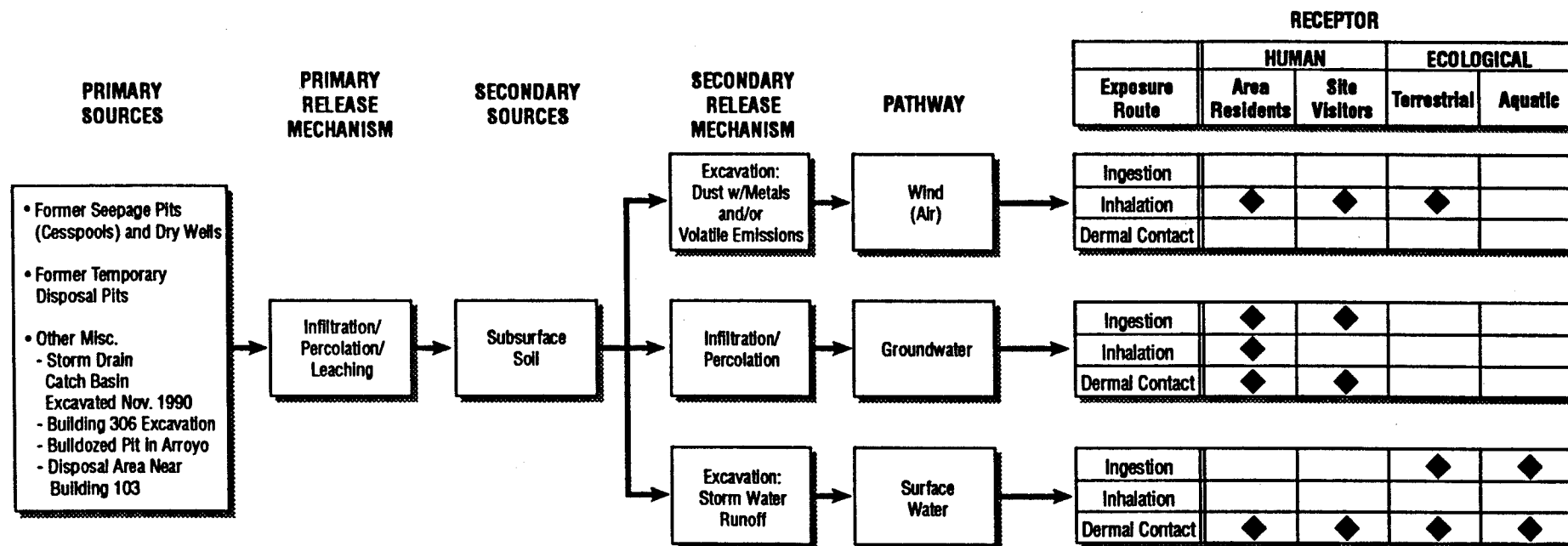


Figure 3 - 3

Conceptual Contaminant Exposure Model
at the Jet Propulsion Laboratory

areas has not provided definitive definition of the specific location(s) that may have created the VOC contamination. The objective of conducting the on-site groundwater effort first is to identify the contaminant source location(s) as quickly as possible so that source characterization conducted as part of the OU-2 effort can be expedited and additional priority given to identified sources of contamination.

The on-site groundwater characterization conducted during the OU-1 RI also will provide JPL the advantage of having a better understanding of the contaminant-transport processes controlling migration off the site. At this time there is not sufficient hydrogeologic data available to determine the nature or extent of VOC contaminants in groundwater east of the OU-1/OU-3 boundary. By completing more of the OU-1 characterization effort, any required modifications to the OU-3 characterization effort can be made.

The OU-3 proposed study described in this work plan has been based on the interpretation of the most logical hydrogeological conditions expected based on the contaminant transport conceptual model. Should that conceptual model change as a result of the OU-1 effort, modifications in OU-3 work will be made to optimize the data collected and maintain the project schedule by avoiding the possibility of drilling additional wells not proposed in this plan. Additional information on operable units is presented in Section 4.2.9 of this work plan.

3.3 CRITERIA FOR OBTAINING ADDITIONAL DATA

After collecting the data proposed in this work plan it may be necessary to obtain additional data to fill the data gaps. This data could include additional soil or soil-vapor samples, groundwater samples, hydrogeologic parameters, and stratigraphic data obtained during the latter stages of the RI. While the FS is in progress, it may also be necessary to obtain additional field or laboratory data as well. When either of these situations occur, NASA will develop a plan for discussion with EPA and CalEPA (DTSC and the RWQCB) that outlines the criteria by which this decision was made along with the technical requirements. Work would be completed after a decision has been reached on the need for additional data pursuant to the FFA process.

3.4 DATA MANAGEMENT

All data generated during the conduct of the JPL RI/FS will be overseen by NASA's Designated Quality Assurance Officer (NDQAO). Standard QA/QC procedures will be implemented by all subcontractors selected to perform drilling, sampling, chemical analyses, and numerical calculations. These procedures are described in length in the OU-specific FSAPs and QAPP. These procedures were developed to comply with both EPA and CalEPA guidelines.

During the implementation of the RI/FS, there will be strict adherence to all specified procedures for sample collection, storage, containerization, and preservation techniques. All samples collected will be transported under a rigid chain-of-custody documentation protocol.

During the sample collection activities and laboratory analyses, chemical data validation will be performed to determine the usability of the laboratory data provided. In this way additional data, or new data to replace data determined to be unusable, can be obtained in a timely manner. The data review process will assess data quality with respect to both technical and contractual requirements. Close examination of analytical data will ensure that:

- All QC requirements (e.g., instrument calibrations, blanks, spikes, recoveries, holding times) were performed and a valid analysis was performed.
- Data are reliable for the intended use(s).

Data obtained during the site investigation will be evaluated as part of the ongoing site assessment as the investigation proceeds. Once all the data from the various field tasks are compiled, an evaluation report of the data will be prepared. This evaluation will ensure the data are sufficient in quality to meet the characterization objectives outlined. Considerations that will be included in the data evaluation are following:

- A historical review of the site including agency reports of incidence, maps, surface photos, notices of violations, and soil reports will be collected and analyzed for pertinent data.
- The location, thickness, and character of areas containing waste will be outlined.
- Site geology will be depicted on a geologic cross-section that will include subsurface data obtained from new monitoring wells. The cross-section will be referenced on a base map.
- Data and maps with groundwater-flow direction will be prepared.

Once the data validation and evaluation are completed by a NASA authorized subcontractor, the NDQAO will maintain the data base. The NDQAO will also control access to the database.

Upon completion of the RI, all raw laboratory data will be presented in the final report. In addition, laboratory QC summaries will also be included.

3.5 REDEFINING OPERABLE UNITS

During the conduct of the JPL RI/FS activities it may be necessary to redefine the boundaries of the three operable units. This does not appear to be a concern at this time. However, if data

is obtained that indicates the need for this to occur, NASA will discuss the need with EPA and CalEPA. NASA will present it's need for redefining the operable unit boundaries in a formal proposal along with information on the potential schedule impacts of such a change for concurrence. NASA will obtain regulatory concurrence (EPA, DTSC, and RWQCB) prior to any schedule changes.

4.0 REGIONAL AND LOCAL JPL SETTING

4.1 REGIONAL JPL SETTING

The regional meteorology, topography, geology, and hydrogeology are discussed in the following subsections. A discussion of potential receptors is also presented.

4.1.1 Regional Meteorology

The Los Angeles Basin, including the area of the JPL site, has a semi-arid Mediterranean climate which is characterized by mild, rainy winters and warm dry summers. Annual precipitation over the Los Angeles region is variable, and averages approximately 15 inches per year (Boyle Engineering, 1988). The majority of the annual precipitation occurs between November through April (80 percent), although summer rainfalls can occur due to tropical disturbances.

Temperatures in the Los Angeles region are relatively mild, with August typically the warmest month and January the coolest. Temperatures can get near a low of 35°F and near a high of 100°F during the year. Wind patterns change seasonally in both strength and direction, in response to normal variations in barometric pressure systems. Generally, winds are mild throughout the year, characterized by breezes from the ocean (onshore) during the day, and land breezes (offshore) at night.

Occasionally, primarily during the fall, the area is affected by "Santa Ana" winds. These winds occur as the result of strong high pressure systems moving into the Great Basin area of Nevada and Utah. These strong land breezes from the northeast create hot and dry conditions due to compressional heating of the atmosphere in the region.

4.1.2 Regional Topography

JPL is located in the San Gabriel Valley in the eastern portion of Los Angeles County approximately 25 miles from the Pacific Ocean. The San Gabriel Valley is bounded on the north by the San Gabriel Mountains, which consist of relatively steep, rocky ridges with numerous canyons. These mountains range from about 900 feet in elevation along their base to a maximum elevation of more than 10,000 feet above sea level.

The San Gabriel Valley itself is a broad plain sloping generally to the south downward from the base of the San Gabriel Mountains. The average slope of the valley floor is about 65 feet per mile.

Immediately south of the San Gabriel Valley, a system of relatively low hills rise about 500 feet from the valley floor to separate the valley from the coastal plain. These hills, from west to east, are the Repetto, Merced, Puente, and San Jose Hills. The hills, broken only at Whittier Narrows by a floodplain approximately 1.5 miles wide, form a crescent shape around the southern edge of the San Gabriel Valley (see Figure 4-1).

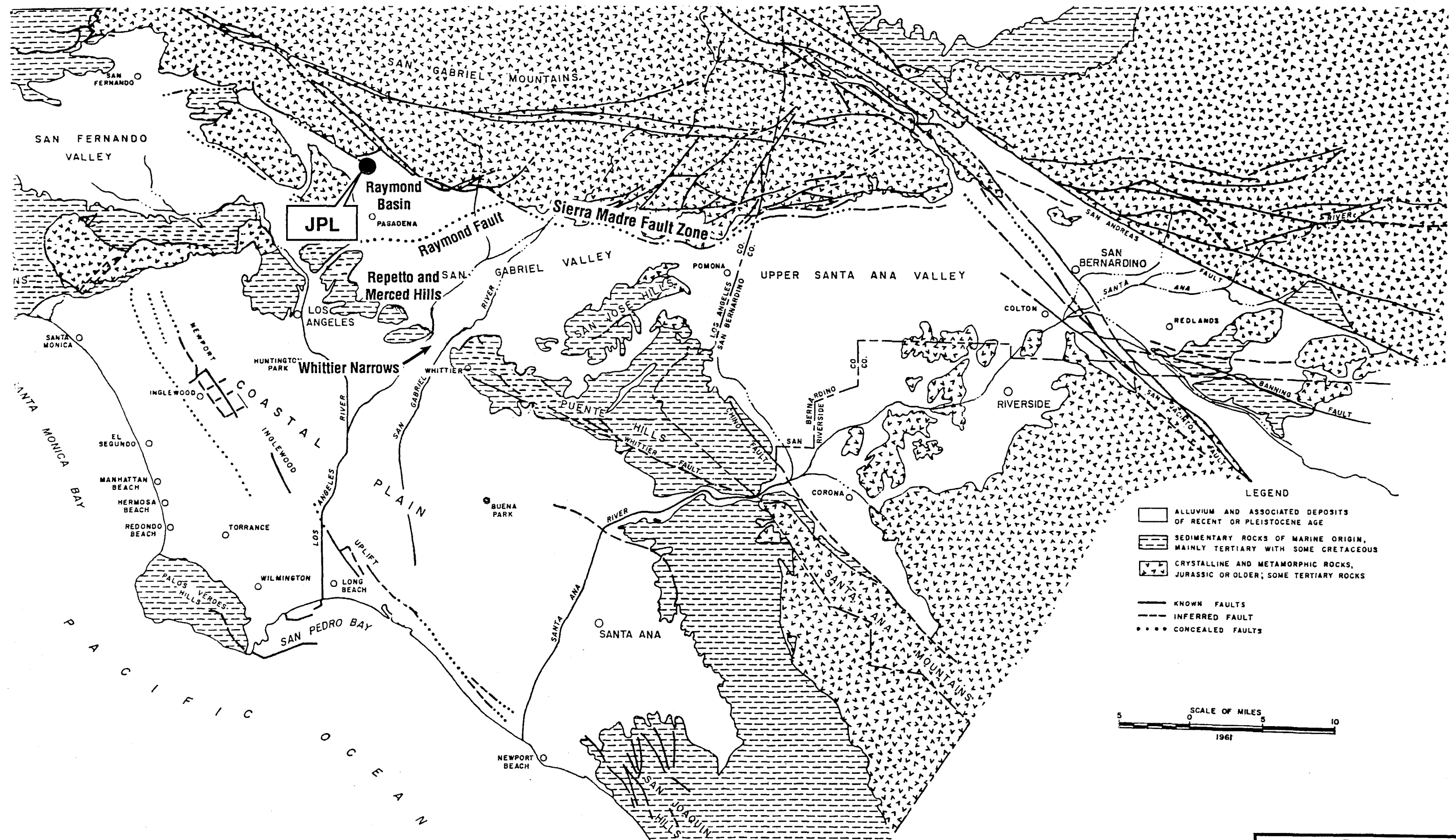
4.1.3 Regional Geology

JPL is located immediately south of the southwestern edge of the San Gabriel Mountains (Figure 4-1). The San Gabriel Mountains, together with the San Bernardino Mountains to the east and the Santa Monica Mountains to the west, make up a major portion of the east-west trending Transverse Range province of California. This province is dominated by east-west trending folds, reverse faults, and thrust faults indicating a history dominated by north-south compressional deformation.

The San Gabriel Mountains are primarily composed of crystalline basement rocks. These rocks range in age from Precambrian to Tertiary and include various types of diorites, granites, monzonites, and granodiorites with a complex history of intrusion and metamorphism. Periodic tectonic uplift of the San Gabriel Mountains has occurred during the past 1 to 2 million years producing the present topography of the area (Smith, 1986). Most of this uplift has occurred along north- to northeast-dipping reverse and thrust faults located along the south to southwest edges of the San Gabriel Mountains. This system of faults along the southern edge of the San Gabriel Mountains is referred to as the Sierra Madre Fault system.

The Sierra Madre Fault system separates the San Gabriel Mountains to the north from the San Gabriel Valley to the south. The San Gabriel Valley contains distinct groundwater basins, including the Raymond Basin where JPL is located. With the San Gabriel Mountains to the north, the Raymond Basin is bounded on the west by the San Rafael Hills and on the south and east by the Raymond Fault (Figure 4-2). The Raymond Fault is a steep, north-dipping reverse fault that lies south of the topographic front of the San Gabriel Mountains.

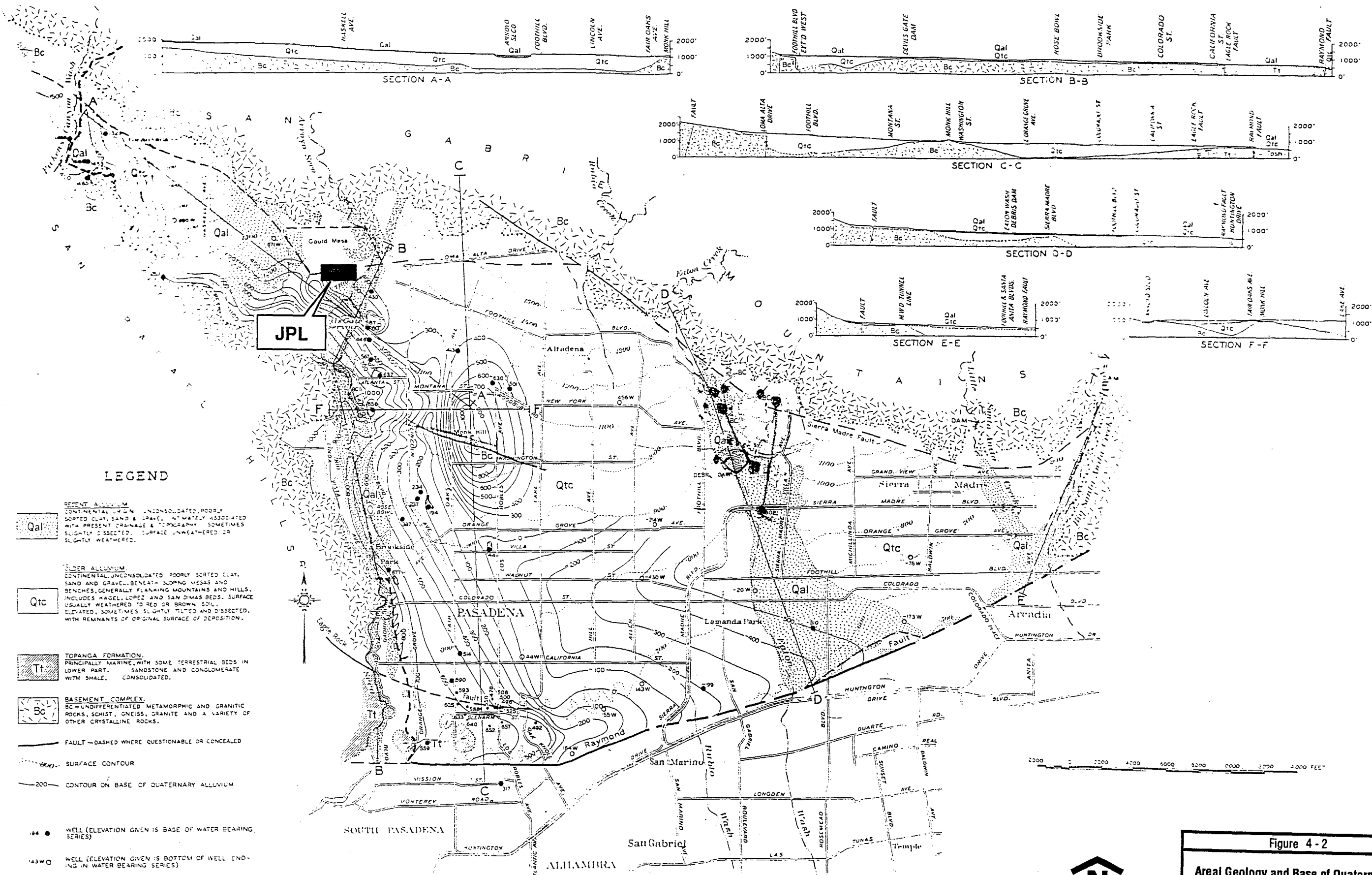
The stratigraphic record of the Raymond Basin prior to the Tertiary period is incomplete. Sediments representing the time period between formation of the crystalline basement complex and sedimentary rocks of early to middle Tertiary age are not present. A generalized stratigraphic column of the Raymond Basin is shown in Figure 4-3.



Source: California Department Water Resources Bull No. 104. Planned Utilization of the Ground Water Basins of the Coastal Plain of L. A. County, 1961.

Figure 4-1

General Geology Surrounding
the Jet Propulsion Laboratory



Source: California Department Water Resources, Raymond Basin Area. Reference, Pas. vs. Alhambra, P.A.C. - 1323, 1939.

Figure 4-2

Areal Geology and Base of Quaternary Alluvium in the Raymond Basin

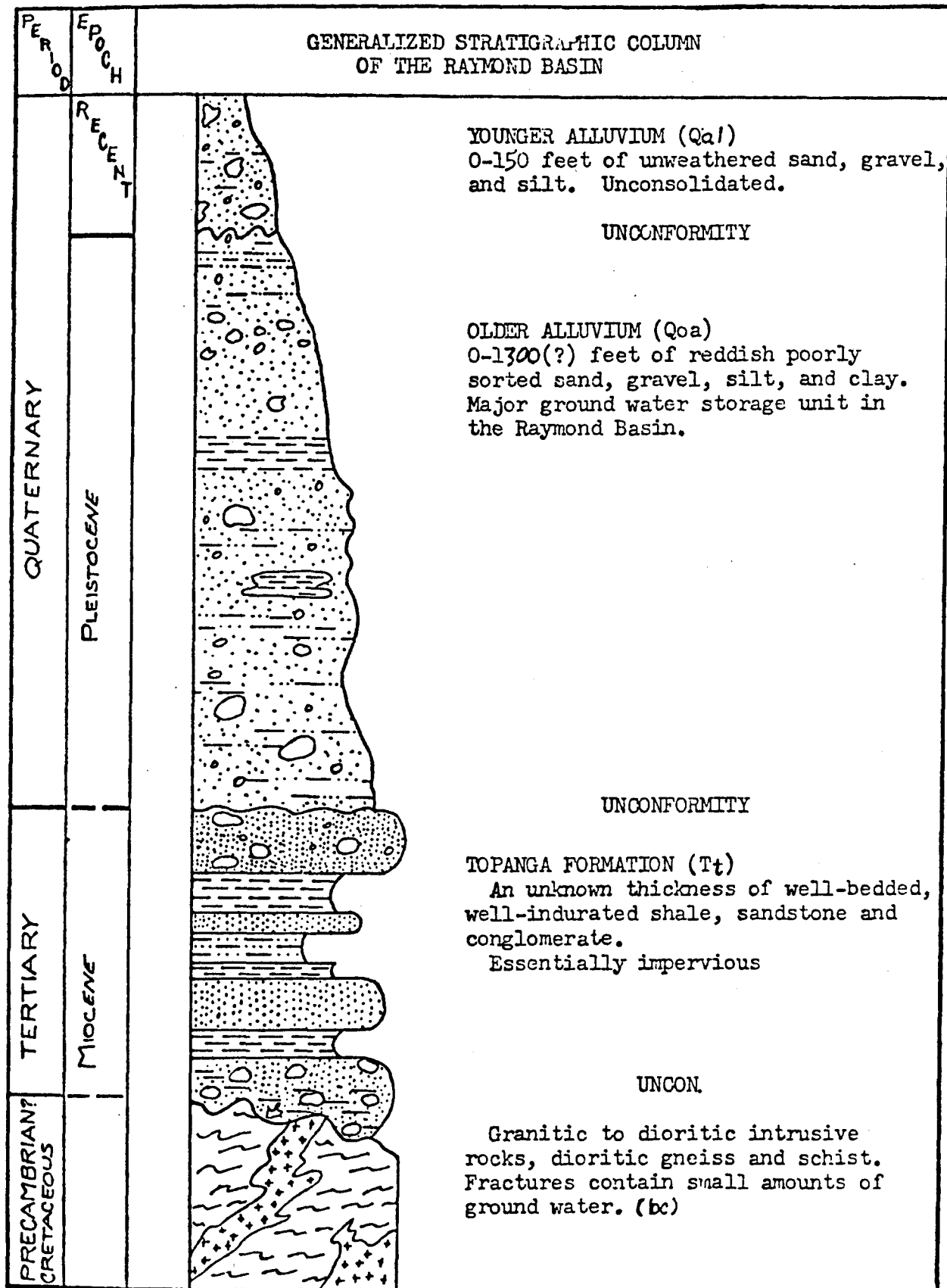


Figure 4 - 3

Stratigraphic Column
of the Raymond Basin

The oldest non-crystalline rocks in the Raymond Basin are in the Topanga Formation. The Topanga Formation comprises a very small part of a fault block in the southwestern corner of the Raymond Basin (Figure 4-2). The formation consists of well-bedded and well-indurated shales, sandstones and conglomerates.

Deposited unconformably on top of the Topanga Formation and the crystalline basement complex is the Pleistocene Older Alluvium. The Older Alluvium is the result of alluvial-plain deposition and is typified by poorly sorted to unsorted, yellowish- to reddish-brown, coarse-grained clastic material derived primarily from the San Gabriel Mountains. The material in these deposits ranges from silt to boulders over 3 feet in diameter. The maximum thickness of the Older Alluvium is not accurately known but is estimated to be up to 1,300 feet.

Lying unconformably upon all underlying units are the unweathered sediments of the Recent (Holocene) Younger Alluvium. The Younger Alluvium is found primarily in the stream beds of the major streams that traverse the basin and consists predominantly of light-gray coarse-grained sands, silts, gravel, and boulders. The Younger Alluvium ranges in thickness from a few inches to roughly 150 feet (DWR, 1969).

4.1.4 Regional Hydrogeology

The San Gabriel Valley contains distinct groundwater basins, including the Raymond Basin. The Raymond Basin is bordered on the north by the San Gabriel Mountains, on the west by the San Rafael Hills, and on the south and east by the Raymond Fault. The Raymond Basin is further divided into three separate subbasins, the Pasadena Subarea, the Santa Anita Subarea, and the Monk Hill Subbasin. JPL is located in the Monk Hill Subbasin (Figure 4-4). The Raymond Basin provides an important source of potable groundwater for many communities in the area including Pasadena, La Canada-Flintridge, San Marino, Sierra Madre, Altadena, Alhambra, and Arcadia.

In the Raymond Basin, alluvial deposits derived from the San Gabriel Mountains contain virtually all the groundwater produced in this region. A review of the geology of the Raymond Basin indicates that the predominant materials present in the basin are the crystalline basement rocks, the Older Alluvium and the Younger Alluvium as shown in Figure 4-2. The only exception to this is a small area at the southwest corner of the Raymond Basin which contains the Topanga Formation. Because of the crystalline nature of the basement complex, groundwater occurs only in joints and fractures in the basement rocks, and, owing to the low porosity in the basement complex, this unit can be considered nonwater-bearing.

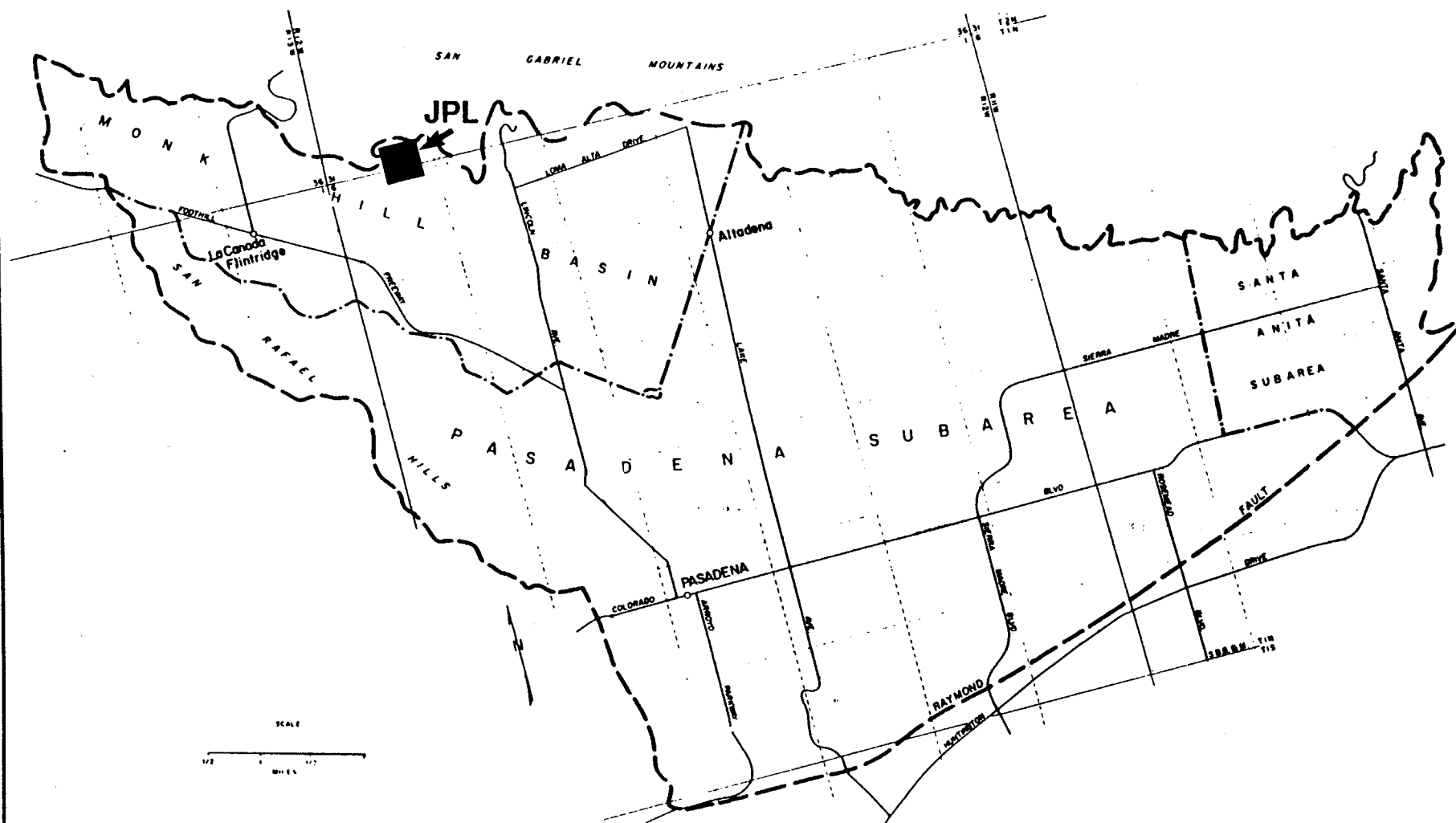


Figure 4 - 4

Hydrologic Subbasins In
the Raymond Basin
(Modified from Nagler, 1985)

--- Limit of Raymond Basin

Throughout the Raymond Basin, groundwater flows in different directions depending on where one is in the basin. Examples of groundwater flow direction are presented in Figure 4-5. In the Monk Hill Subbasin, groundwater flow is generally southeast. JPL is located near the northern edge of the Monk Hill Subbasin where a confluence of groundwater flow regimes occurs. West of JPL, the groundwater flow is predominantly to the southeast, and east of JPL the groundwater flow is predominantly to the south-southwest.

Located within the Raymond Basin are several water-spreading grounds and municipal water production wells. Their locations are shown in Figures 4-6 and 4-7 respectively. The presence of the spreading grounds and production wells locally influence the configuration of the water table.

The estimated regional hydraulic gradient in the Raymond Basin ranges from 200 feet per mile to 100 feet per mile (Raymond Basin Management Board, 1985). The average transmissivity of the underlying aquifer ranges from approximately 50,000 gallons per day per foot (gpd/ft) in the La Canada Valley to about 200,000 gpd/ft near the Arroyo Seco and Devil's Gate Dam (Raymond Basin Management Board, 1985).

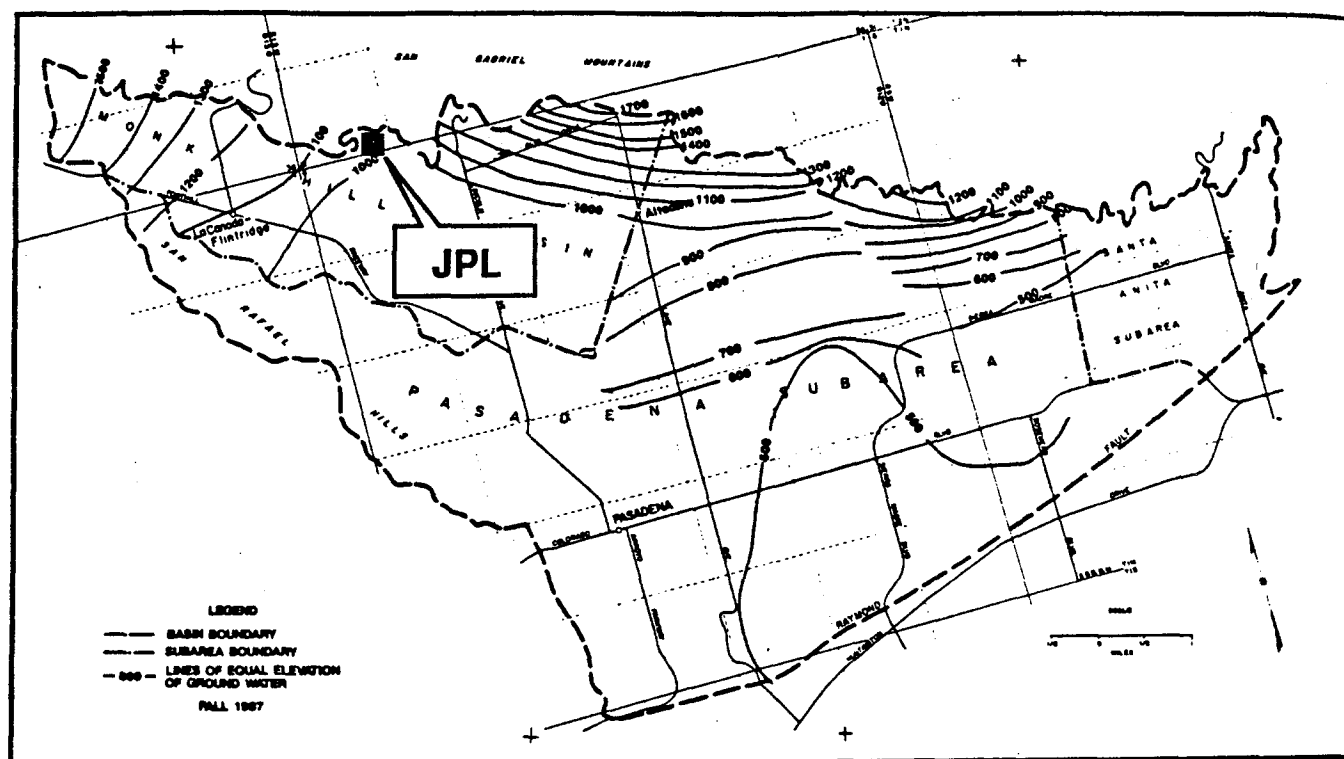
4.1.5 Off-site Receptors Exposure Pathways

Both potential off-site human and ecological receptors and exposure pathways are discussed in the following sections. A discussion of the on-site receptors exposure pathways is presented in Section 4.2.7 of this work plan.

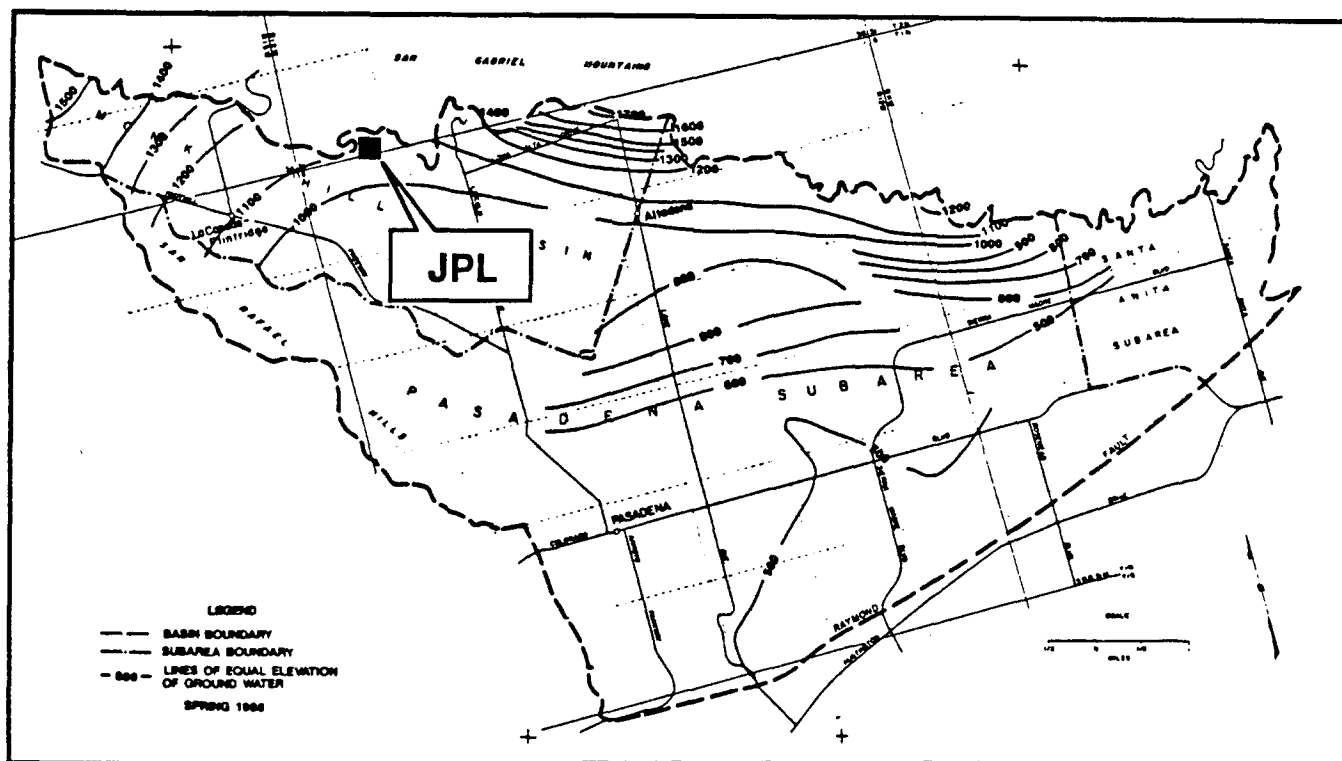
Human Receptors

The most likely off-site exposure medium is untreated contaminated drinking water. Four Pasadena public supply wells are located approximately 1,200 to 2,400 feet downgradient of the site and include the Arroyo Well, Well No. 52, the Ventura Well, and the Windsor Well (identified as M1, N3, N1, and D2, respectively, in Figure 4-7 immediately southeast of JPL). Volatile organic compounds (VOCs) have been detected in three of these wells. These contaminants are similar to contaminants that have been detected in JPL on-site monitoring wells.

One potentially exposed off-site population has been identified for the JPL site. The city of Pasadena residents who are supplementally supplied in the summer months with tap water from the three contaminated city wells (Arroyo, No. 52, and Windsor) may be exposed to site contamination. This population may come in contact with site contamination from showering



Lines of Equal Elevation of Ground Water, Fall 1987

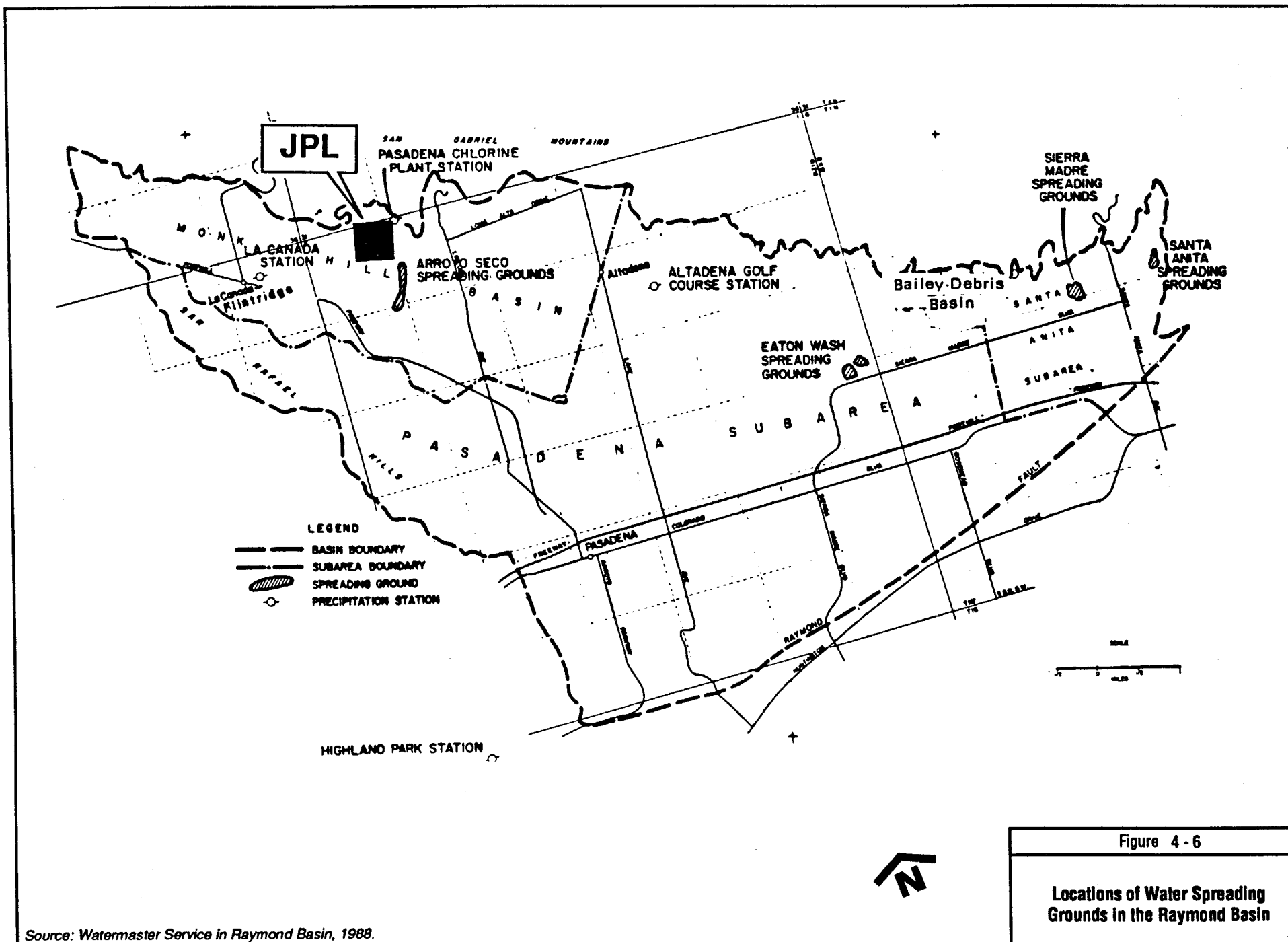


Lines of Equal Elevation of Ground Water, Spring 1988

Figure 4-5

Typical Contour Maps of
the Groundwater Table
in the Raymond Basin

Source: Watermaster Service in Raymond Basin Report, September 1988.



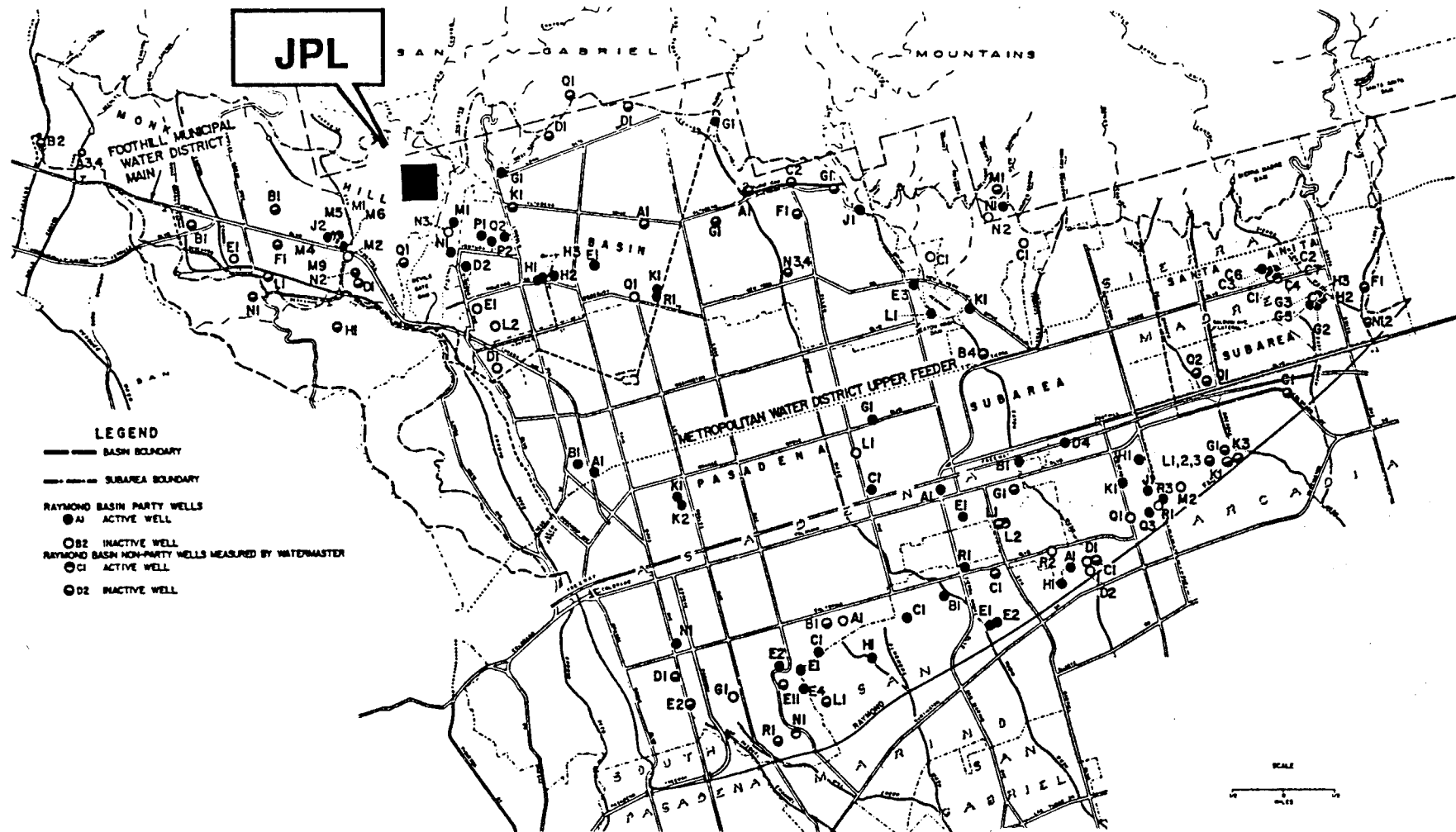


Figure 4 - 7

**Locations of Municipal Water
Production Wells in the
Raymond Basin**

in, washing with and drinking of untreated groundwater. Therefore, exposure routes for this population may include inhalation, dermal contact, and ingestion.

JPL has funded the installation and operation of a groundwater treatment system to treat water from the four Pasadena public supply wells located directly downgradient. Two Altadena public water supply wells (Lincoln Avenue Water Company wells) are also contaminated with VOCs.

Other potential, but less likely, off-site exposures include inhalation of contaminated air (VOCs and particulate soil), and direct contact with or incidental ingestion of contaminated soils or surface waters. If on-site subsurface soil excavation occurs in the future, then the population in the immediate vicinity of the site could be exposed to volatilized site contaminants. In addition, airborne particulate soil could be inhaled, incidentally ingested, and dermally contacted by this off-site population.

The potential human exposure to surface runoff of contaminated soil into the Arroyo Seco will be evaluated in the Baseline Risk Assessment (BRA). In general, since most of the contaminants at JPL are believed to have been disposed of in subsurface seepage pits, the potential for surface runoff contamination appears to be minimal.

Ecological Receptors

An ecological survey of the JPL site will be performed to assess the need for a more detailed ecological assessment. If the survey indicates that site contamination is resulting or may result in potentially harmful exposures to ecological receptors, then a full quantitative ecological risk assessment will be performed. The scope of the ecological risk assessment is addressed in Section 8.1.6.

Based on a preliminary survey conducted, there are currently potentially four endangered, and two threatened species inhabiting the area surrounding the JPL site (US Fish and Wildlife Service, April 1993). Species in these categories are listed in Table 4-1.

TABLE 4-1
THREATENED AND ENDANGERED SPECIES
INHABITING JPL AREA

Common Name	State	Federal
FLORA:		
Nevin's Barberry	E	
Slender-horned Spineflower	E	E
Gambel's Watercress		T
FAUNA		
Western Yellow Billed Cuckoo	E	
Bank Swallow	T	
Least Bells Vireo	E	E

Note:

T - Threatened
E - Endangered

Exposure pathways for ecological receptors will be evaluated during the RI/FS. Exposures will be evaluated for all contaminants which are selected as ecological contaminants of concern (COCs). No volatile organic contamination has been detected, to date, in sediments or subsurface soils. Metals were detected in subsurface soils on the site and in surface sediments in the Arroyo Seco. Mercury was only detected in downgradient sediments at a level of 0.13 mg/kg, or about an order of magnitude greater than what may be expected in a typical sandstone or granite. To assess the significance of inorganic chemicals detected in soil, background soil samples will be collected and analyzed for comparative purposes during the RI. Total petroleum hydrocarbons (TPH) were detected in soils from the Arroyo (up to 71 mg/kg), but were also detected in an upgradient soil sample (14 mg/kg) (see Section 5.1.9). The extent of TPH and its potential ecological impact will be assessed during the RI/FS.

A natural preservation and water capture resource project is planned southeast of the site. The project has been called the Devils Gate Dam Multi-Use Project (DGDMUP). This project forms the basis of a new regional park called Hahamongna Park. The activities planned include reservoir clean-out, flood handling facility reconfiguration, Devil's Gate Dam rehabilitation, and wildlife habitat establishment and enhancement (Ebasco, 1990b). Wildlife in the proposed new habitat may become exposed to contaminated surface and subsurface soils and will, therefore, be considered during the ecological survey of RI/FS.

4.1.6 Potential Off-Site (Regional) Expedited Response Actions

The use of expedited response actions to control or treat off-site contaminated groundwater was implemented in 1991. NASA funded the construction of a water treatment plant for the Pasadena public supply wells to treat VOCs in groundwater pumped from those wells.

The treatment system was designed to remove or reduce volatile organic compounds in the groundwater, prior to release to the municipal water supply system. Specifically, water removed from the nearby municipal water wells, is transported by pipeline to an air-stripping tower located near the Ventura well. After treatment, the water is discharged into a local reservoir near the Windsor Well for subsequent release to the municipal water supply system. This treatment system is operated any time pumping of the four Pasadena public supply wells occurs.

4.2 LOCAL JPL SETTING

Discussions in following subsections include the local meteorology, local topography, local geology, local hydrogeology, potential on-site exposure points, potential expedited response actions, identification of RI/FS operable units, and preliminary identification of remedial action objectives and alternatives as they relate to JPL.

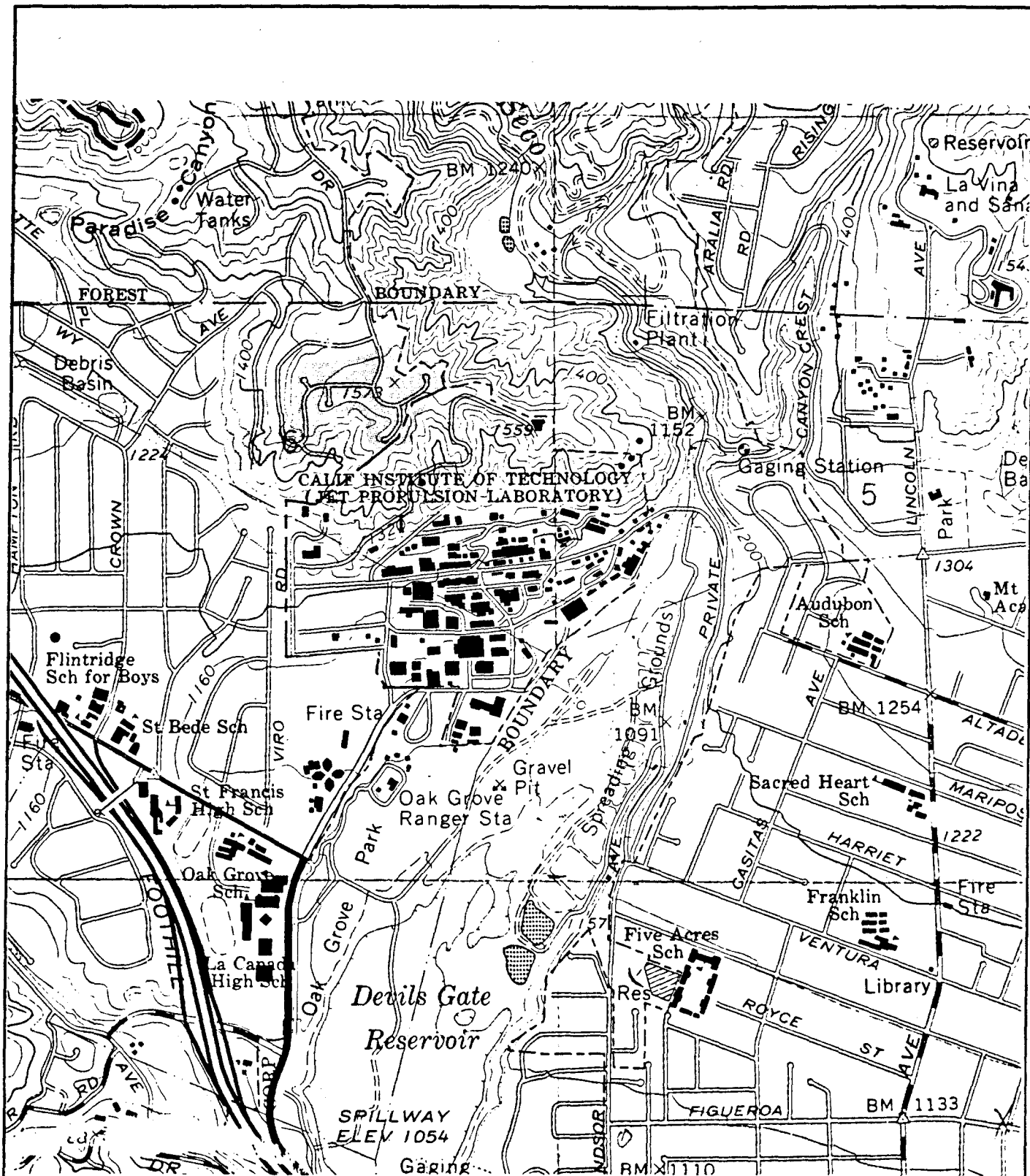
4.2.1 Local Meteorology

Similar to the Los Angeles region, JPL has a semi-arid Mediterranean climate which is characterized by mild, rainy winters and warm dry summers. Rainfall in the vicinity of JPL is higher than for the City of Los Angeles, averaging about 20 inches per year. The higher amounts of rainfall near JPL is a result of orographic effects of the nearby San Gabriel Mountains. The majority of the annual precipitation (80 percent) occurs between November through April.

Temperatures at JPL are relatively mild, with August typically the warmest month and January the coolest. The minimum recorded mean monthly temperature in the JPL area was 32.5°F in January 1937 and the maximum mean monthly temperature was 95.5°F in August, 1929 (CDM, 1980). Extremes for the area range from about 30°F in December to 110°F during the summer months.

Similar to the Los Angeles region, wind patterns around JPL change seasonally in both strength and direction, in response to the normal variations in barometric pressure systems. Generally, winds are mild throughout the year, characterized by breezes from the ocean (onshore) during the day and land breezes (offshore) at night.

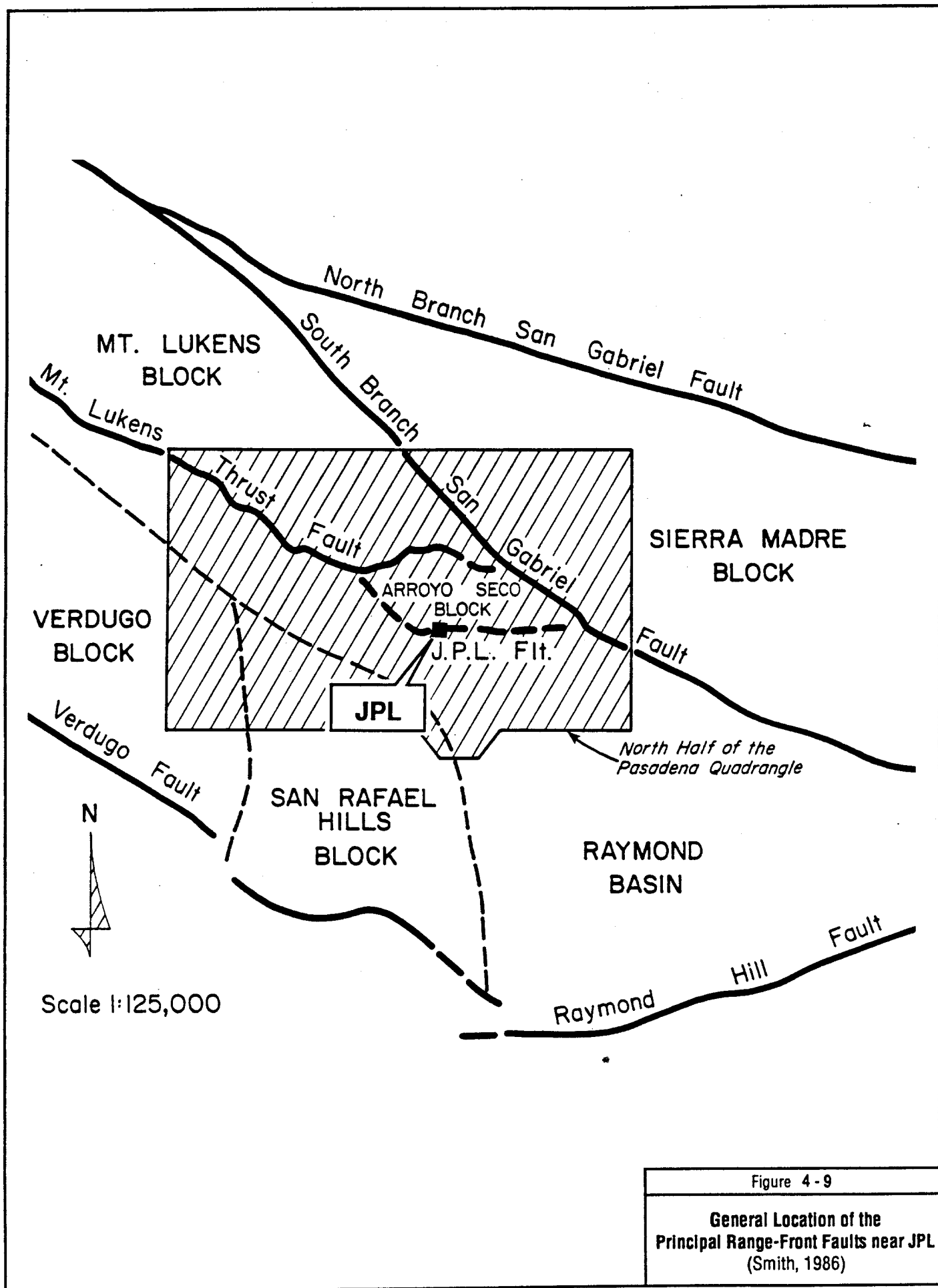
Also similar to the Los Angeles region, occasionally during the fall JPL is affected by "Santa Ana" winds. These winds occur as the result of strong high pressure systems moving into parts of Nevada and Utah creating strong hot and dry winds from the northeast. Near the mouth of canyons oriented along the direction of airflow, these winds can be particularly strong. Winds

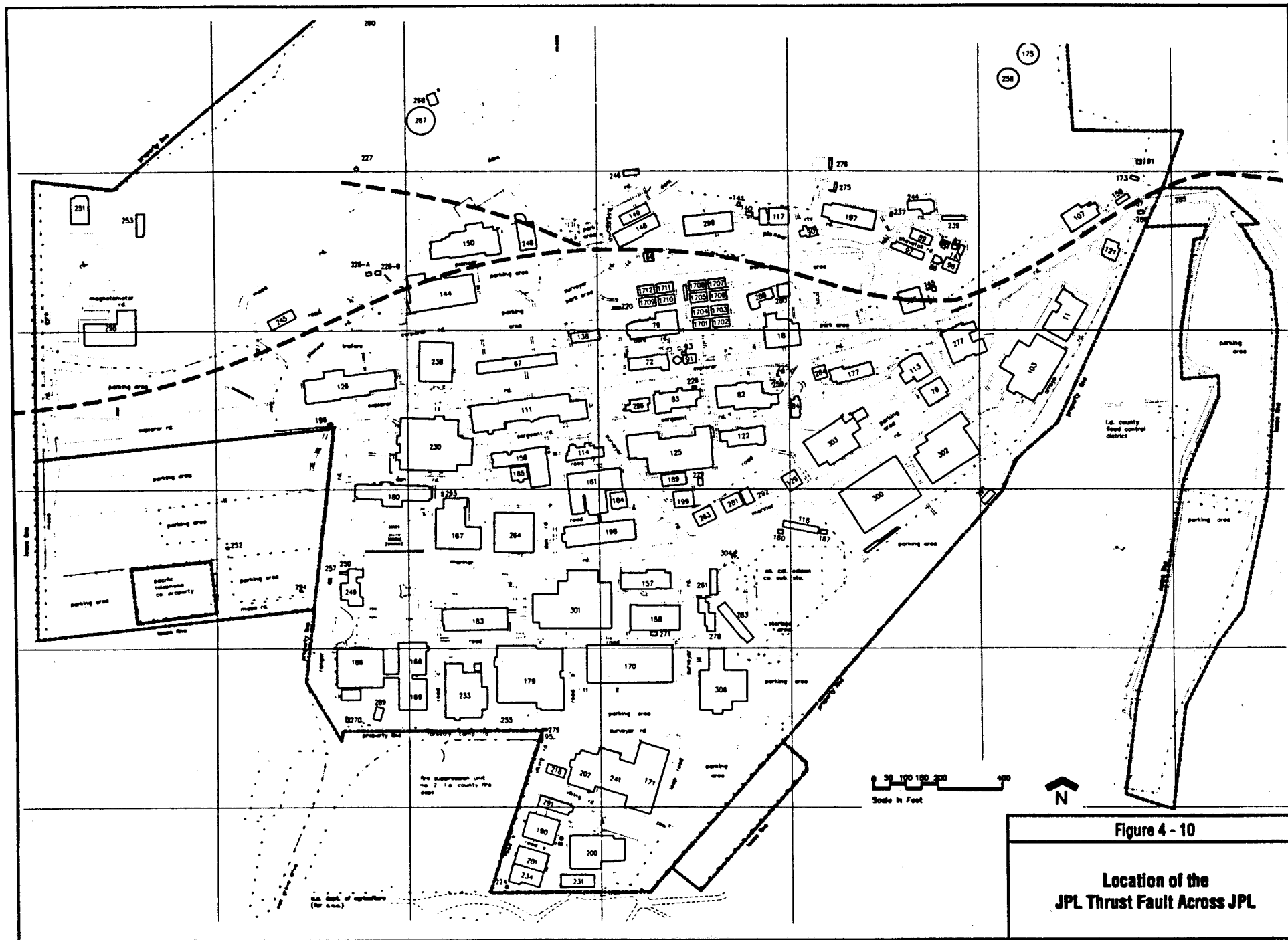


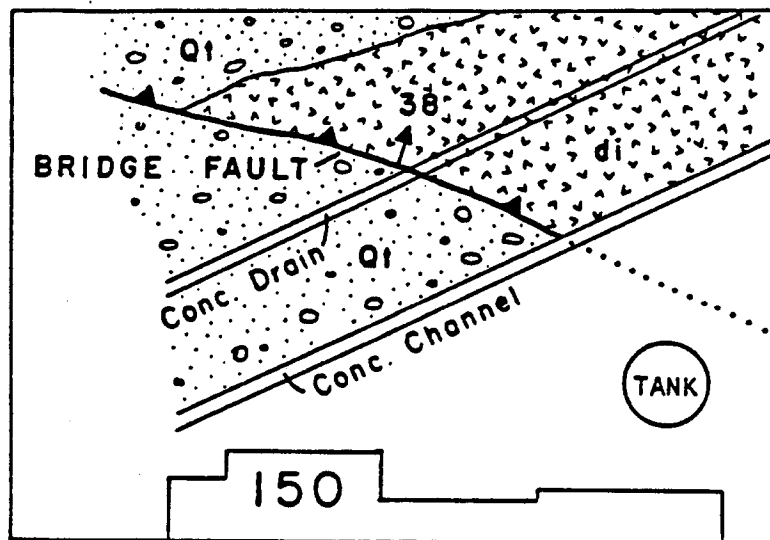
Contour Interval: 40 ft.
 Scale: 1" = 1300 ft. Approximately
 Source: U.S. Geological Survey, Pasadena, California Quadrangle, 1966.

Figure 4-8

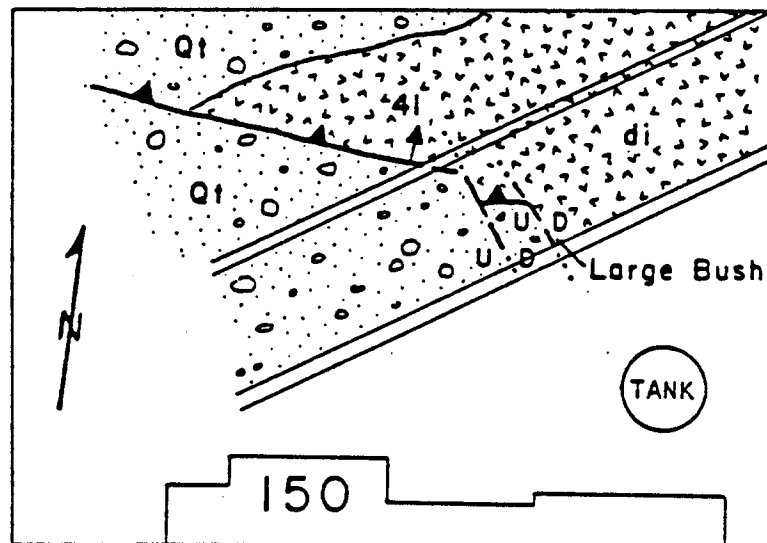
Topographic Map of JPL
 and Surrounding Areas







(a) As mapped by Converse, et. al., 1971



(b) As mapped by Agbabian Associates, 1977

0' 50' 100'

- Qt = QUATERNARY TERRACE DEPOSIT
- di = DIORITE
- 38, 41 = DEGREES OF FAULT INCLINATION FROM THE HORIZONTAL
- U = RELATIVELY UPWARD DISPLACEMENT OF FAULT WALL
- D = RELATIVELY DOWNWARD DISPLACEMENT OF FAULT WALL

Figure 4-11

JPL Fault as Mapped
Behind JPL Building 150
(Agbabian, 1977)

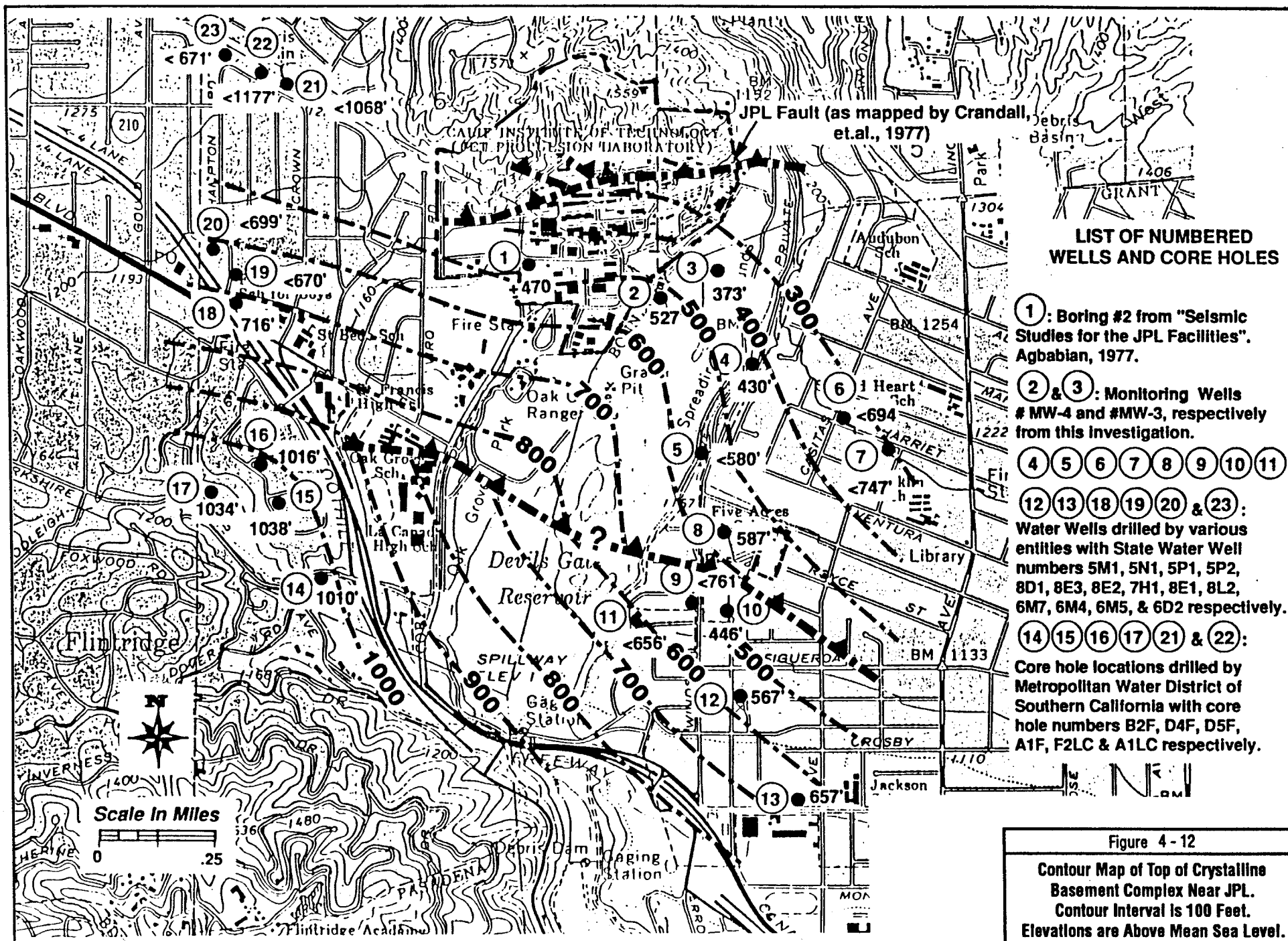
found at the contact between granitic alluvium at the foot of the hill behind JPL and the crystalline basement (diorite at this location) above it. In general, the exact trace of most of the JPL Thrust Fault and its associated branch is not known, but the fault appears to be a north-dipping (approximately 40 degrees) reverse fault which commonly places the crystalline basement complex over Older Alluvium.

On the north side of the main branch of the JPL Thrust Fault, behind building 150, three shallow wells were installed as part of a soil dewatering system (Crandall et al., 1981). During the drilling of these wells, crystalline basement rocks were reached from 2 to 20 feet below grade. This indicates that very little alluvium is present in this area north of the main branch of the fault. Just south of the JPL Thrust Fault, monitoring well MW-7 was installed to 275 feet (Ebasco, 1990a) and never reached basement rock. However, some nearby City of Pasadena municipal production wells and two of the deep monitoring wells installed at JPL have reached basement south of the JPL Thrust Fault between 550 feet and 725 feet below grade. Figure 4-12 is a contour map of the top of the crystalline basement complex south of the JPL Thrust Fault based on existing data from the JPL and Pasadena wells. As indicated in this figure, the basement complex dips to the north.

Beneath JPL, Pleistocene Older Alluvium is present from the ground surface down to the top of the basement complex. The Older Alluvium is the result of alluvial-plain deposition and is typically poorly sorted to unsorted, yellowish- to reddish-brown, coarse-grained clastic material derived from the San Gabriel Mountains. The material in these deposits range from silt to boulders over 3 feet in diameter. Bedding is very poorly developed in the alluvium where the percentages of silt, sand, gravel, cobbles, and boulders fluctuate throughout the stratigraphic column. A summary of the field boring logs for the on-site deep monitoring wells MW-4 and MW-11 are presented in Figure 4-13 to illustrate the variable nature of the alluvium.

The alluvial deposits may be associated with braided-river environments, intermittent stream action, and periodic flooding. Sediments deposited by the action of streams typically show abundant scour-and-fill structures and crudely developed near-horizontal bedding. However, features of this detail are difficult, if not impossible, to discern with the type of drilling program required at JPL. Correlation of rock types between monitoring-well locations is nearly impossible because of the variable nature of the sediments. The maximum thickness of the Older Alluvium beneath JPL is estimated to be over 800 feet.

Lying unconformably upon the Older Alluvium in the Arroyo Seco wash is the unweathered sediments of the Recent (Holocene) Younger Alluvium. The Younger Alluvium consists predominantly of light-gray coarse-grained sands, silt, gravel, and boulders.



4.2.4 Local Hydrogeology

JPL is located within the Monk Hill Subbasin of the Raymond Basin. The basin has been separated from the Pasadena Subarea along a line that trends northeast from Monk Hill (Figure 4-2). The remainder of the boundary separates an area of gentle hydraulic gradient from one of steepening gradient. The lines of demarcation between subbasins, though somewhat arbitrary, represent general locations of subtle groundwater gradient changes or divides.

The Older Alluvium deposits beneath JPL comprise the local groundwater reservoir. The Older Alluvium deposits throughout the basin have historically provided virtually all of the groundwater produced in the region. The City of Pasadena has installed several municipal water production wells in the Monk Hill Subbasin that extract groundwater strictly from the saturated sections of the Older Alluvium.

Underlying the Older Alluvium beneath JPL is the crystalline basement complex, comprised of the same general rock types that are exposed in the San Gabriel Mountains to the north of JPL. Because of their crystalline nature, groundwater can only occur in fractures or joints. As a result, the bedrock units are considered to be nonwater-bearing.

The groundwater table beneath JPL has been measured in on-site monitoring wells (south of the JPL Thrust Fault) at depths ranging from approximately 30 feet to 270 feet below ground surface. Locations of monitoring wells at JPL, and the total depth each was drilled, are shown in Figure 4-14. This wide range of depth to groundwater is related to the steep topography present at JPL and to the effects from municipal production wells and the Arroyo Seco Spreading Grounds near JPL (Figure 4-8). In a monitoring well installed in the Arroyo Seco near the eastern boundary of JPL (MW-3), bedrock was reached at a depth of about 725 feet below grade.

Groundwater below JPL flows predominantly to the east and southeast across the Monk Hill Subbasin, with an average gradient of about 40 feet per mile (0.008 ft/ft). However, the groundwater flow direction and gradient below JPL can change. The nearby City of Pasadena municipal production wells and the Arroyo Seco Spreading Grounds have large influences on the local groundwater table. Groundwater elevation contour maps from four periods of time are presented in Figure 4-15 to illustrate how significantly the groundwater table can change. For example, water levels were measured in the monitoring wells at JPL in September 1990 when the City of Pasadena began pumping four of their production wells located near JPL for the first time after several years of no activity (Ebasco, 1990c). Water levels in the JPL monitoring wells were drawn down from 10 to 40 feet immediately after the city wells began pumping as

Monitoring Well MW-4

Monitoring Well MW-11

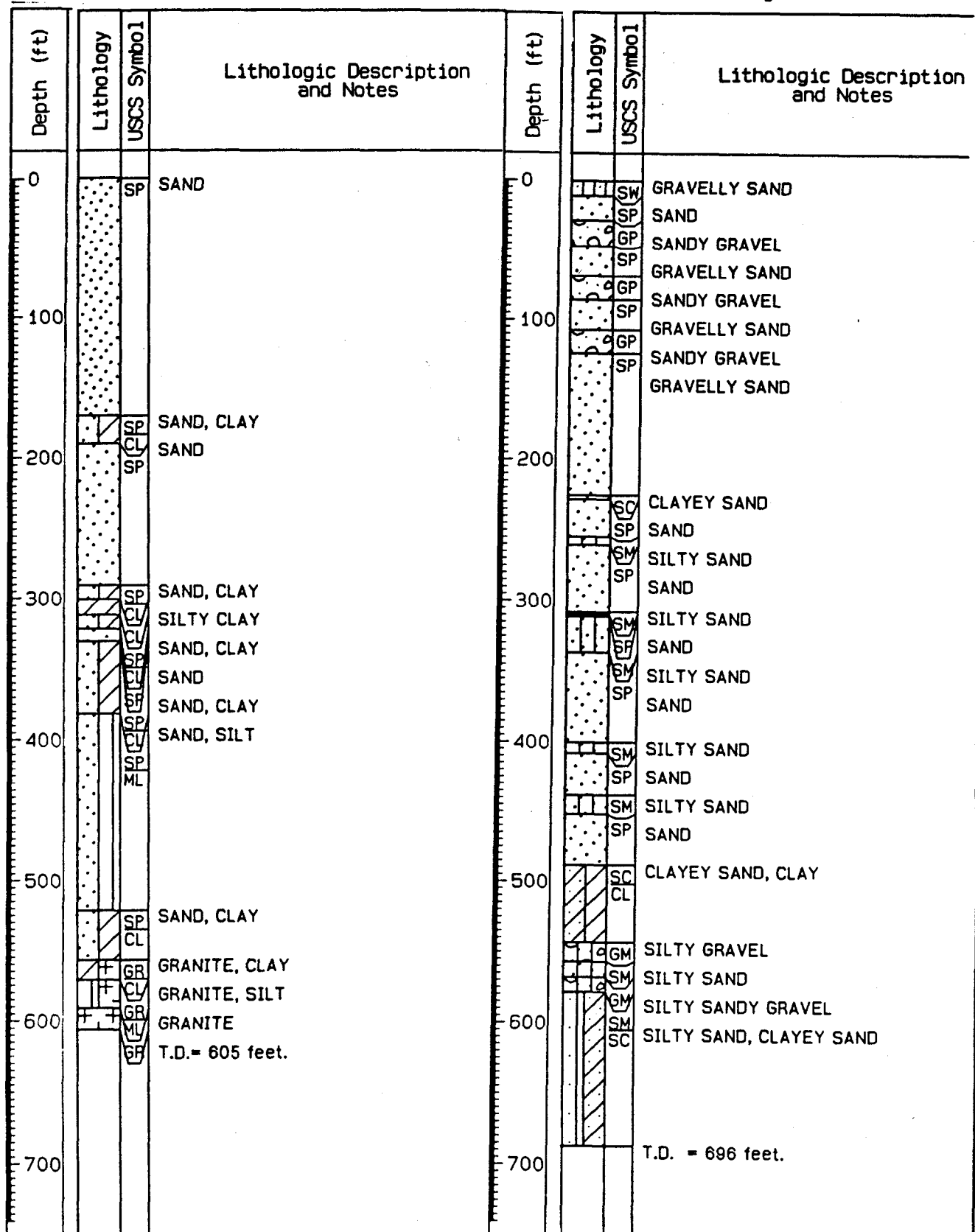


Figure 4 - 13

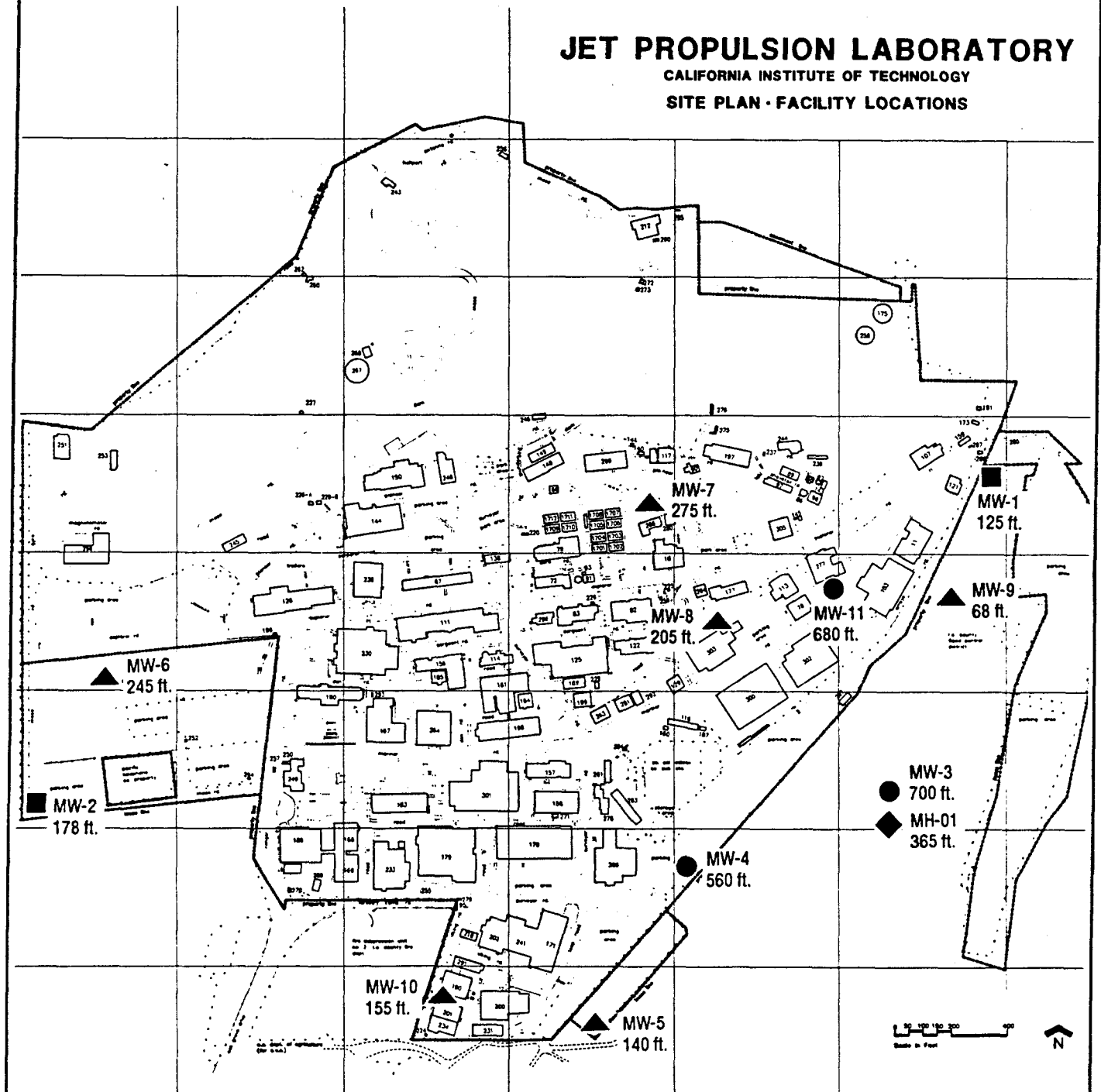
Summary of Field Boring Logs for
Monitoring Wells MW-4 and MW-11
Jet Propulsion Laboratory

Note: Complete lithologic descriptions are included in Appendix A.

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

SITE PLAN - FACILITY LOCATIONS



- ◆ Installed by Geotechnical Consultants, Inc., in 1982
- Installed by Geotechnical Consultants, Inc. in 1989
- ▲ Shallow, Single-Screen Wells installed by Ebasco
- Deep, Multi-Screen Wells Installed by Ebasco

Figure 4 - 14

Locations and Total Depths
of Groundwater Monitoring
Wells at JPL

shown in Figure 4-16. The 10-foot drawdown was observed in well MW-6, which is about one half mile from the production wells.

During the rainy months, when the Arroyo Seco spreading grounds are used, a groundwater mound, or ridge, in the Arroyo Seco can form beneath the spreading grounds reversing the local groundwater gradient beneath JPL. At times, the water flows to the west from the Arroyo Seco as opposed to the east. This is shown on Figure 4-15 for the dates of April 5-6, 1993. Water table elevations collected from JPL monitoring wells since measurements began in early 1990 are illustrated on Figure 4-17. As indicated in Figure 4-17, the groundwater flow was reversed, or flowed to the west, below JPL based on measurements made in early 1992 and early 1993.

The aquifer below JPL is considered unconfined. However, observations of potentiometric surfaces from individual screened intervals in the on-site JPL deep multi-port wells show vertical head variations of up to 5 feet with a gradient on the order of 0.01 ft/ft from top to bottom. It is probable that these observed head differentials are the result of minor variations in hydraulic conductivities within the aquifer manifesting an inverse relationship between head and hydraulic conductivity. There is little evidence to date to suggest there is an order to this vertical variability.

The extent of influence that faults at JPL have on the local groundwater flow is still not fully understood. The JPL Thrust Fault is the boundary between the crystalline San Gabriel Mountains to the north and the alluvium to the south. North of the fault, a shallow groundwater system is present in the thin unconsolidated soils that have formed over the bedrock. More detailed information regarding groundwater elevations adjacent to this fault are needed to evaluate the role the fault plane may play in groundwater movement. It is likely that the fault planes at JPL do not influence local groundwater movement since sandy alluvium has been faulted adjacent to sandy alluvium without apparent appreciable fault gouge. However, it is possible a clay rich gouge can form creating a groundwater barrier along fault planes. It appears likely that the local groundwater movement is influenced by the depth and the geometry of the local crystalline basement complex, and not by the fault planes themselves. The shallow groundwater north of the JPL Thrust Fault is likely the result of the shallow basement north of the JPL Thrust Fault, and may not be related to a potential barrier formed along the JPL Thrust Fault plane. This shallow groundwater north of the JPL Thrust Fault appears to be small in volume and may not be significant in terms of influencing groundwater flow directions or gradients across most of JPL. It is possible that contaminant source areas may be located above this shallow aquifer and that this shallow aquifer may contribute contaminants to the contaminant plume(s) beneath JPL.

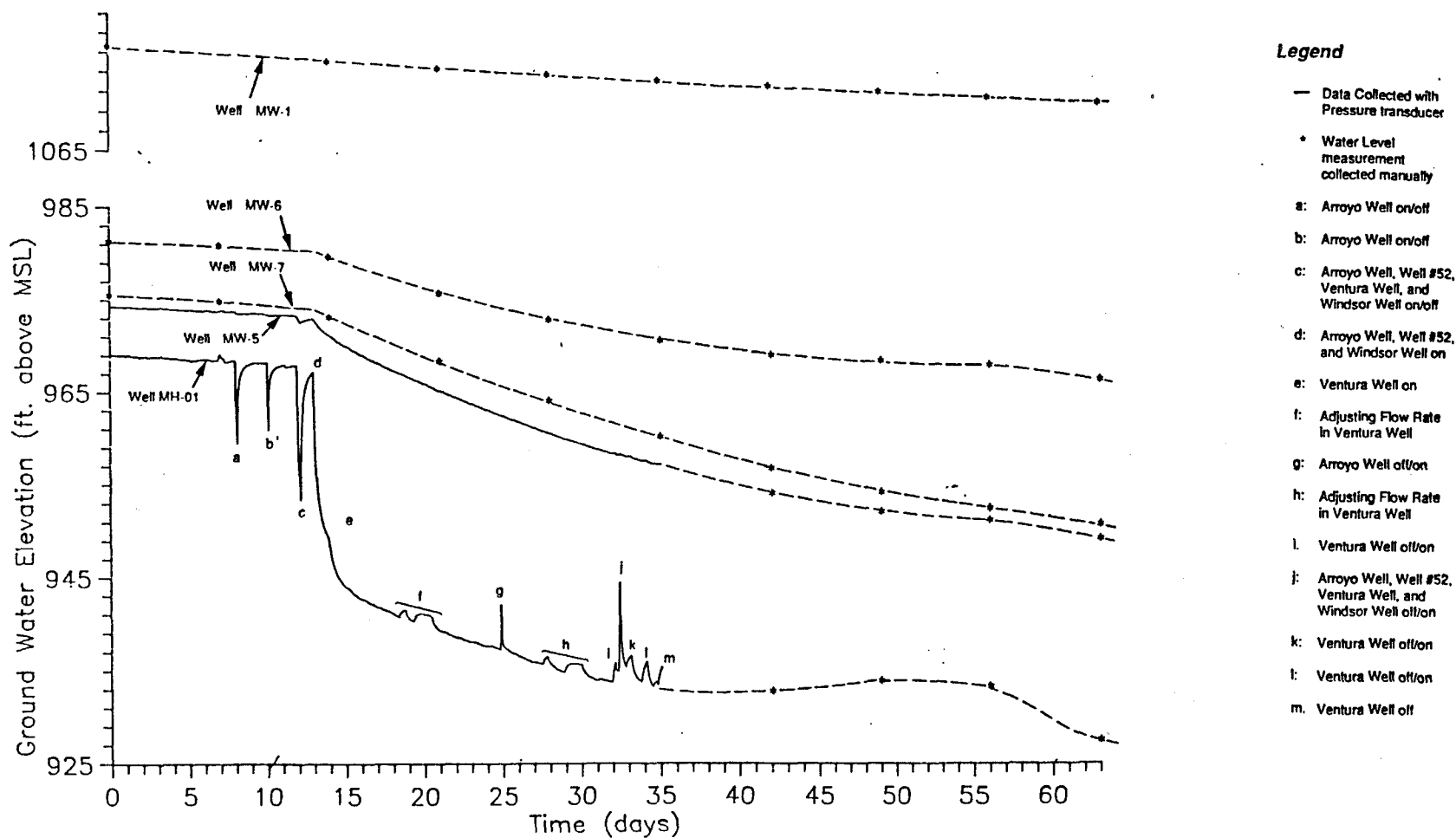


Figure 4 - 16

Groundwater Elevation Versus Time
for Monitoring Wells at JPL During
Start-Up of City of Pasadena
Groundwater Treatment Plant

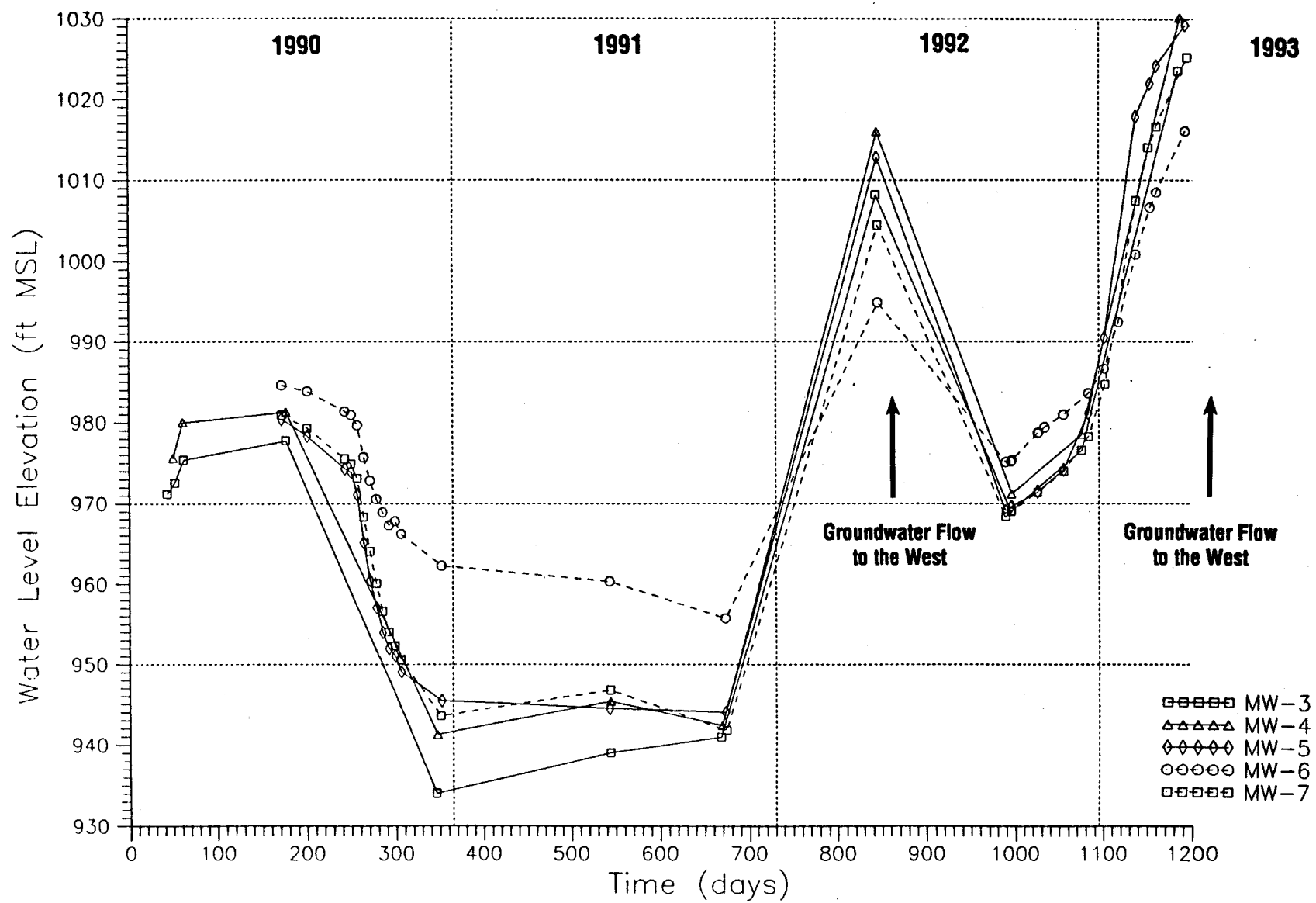


Figure 4 - 17

Water Table Elevations in
Monitoring Wells at the
Jet Propulsion Laboratory

4.2.5 Areas of Concern

The field work proposed for the RI is designed to address three main areas of concern: (1) the identification and characterization of contaminants, their extent and locations, in the vadose zone in soil; (2) the identification of the nature and extent of contaminants in the groundwater underlying JPL and the surrounding areas; and (3) collection of the necessary data to perform a baseline health risk assessment for the JPL site.

Determining the contaminant source areas at JPL is a critical component in developing the RI/FS approach. All subsequent work concerning the risk assessment, contaminant fate and transport, and assumptions for remedial-action alternatives will rely on adequate characterization of the source areas. Information on what constituents, the amount of each constituent and the locations of the constituents are required. Because of surficial changes at JPL over the years, such as building demolition and construction, erosion, excavation, etc., in areas where waste disposal may have occurred in the past, and uncertainties about precise disposal locations, a number of sampling methods may be necessary to fully characterize the contaminant sources. In some cases, a soil gas survey will be used to explore a potential source area and help delineate extent and hot spots. This activity would then be followed by confirmation soil borings. Finally, periodic monitoring will be performed in select locations where the borings were finished as vapor monitoring wells.

The groundwater characterization component of the RI is focused on further determining where contaminants may occur, the vertical and horizontal extent of contaminants, and the concentrations of contaminants. This is made more difficult by the dynamic nature of the groundwater tables. As shown in Figures 4-15 through 4-17, influence from the Arroyo Seco, the Spreading Grounds and nearby City of Pasadena municipal water production wells on the water table beneath JPL can be significant. In addition, the Devil's Gate Dam Multi-Use Project (DGDMUP) located south of JPL, is expected to dramatically impact the configuration of the groundwater table that surrounds JPL.

4.2.6 Types and Volumes of Wastes Present

After reviewing reports of previous investigations and interviewing former and current JPL employees, there was evidence that the soil and groundwater contamination present today is a likely result of waste generation and disposal practices used in the 1940s and 1950s.

During the 1940s and 1950s, seepage pits (cesspools) were used to dispose of liquid and solid wastes from lavatories, drains, and sinks at many JPL buildings. These seepage pits were designed to allow liquid wastes to seep into the surrounding soil. Many of these seepage pits

may have received various quantities of chemicals used at the facility. Although the seepage pits were abandoned in the late 1950s and early 1960s when a sewer system was installed, a number of these seepage pits may be the original source of contaminants currently detected in the groundwater at JPL. From a review of JPL facility records and interviews with current and former JPL employees, 40 seepage pits have been identified. A review of the historical research and interviews is provided in Section 5.0.

In addition to the seepage pits, other localized sources appear to be present. In November 1990, during construction activities near the east gate of JPL, a concrete storm drain catch basin was excavated and found to contain several volatile organic compounds. Also, southeast of Building 248, three hand-dug holes, approximately 25 feet apart and each measuring about 4 feet across by 3 feet deep, were reportedly used for 2 or 3 years in the late 1950s for the disposal of solvents. Approximately three 55-gallon drums consisting of various concentrations of solvents were dumped into the holes every 3 to 4 months.

During this same time frame, a large shallow depression bulldozed in the Arroyo was used for solid-waste disposal. This disposal was on city land and managed by the City of Pasadena. An erosion channel near Building 103 was reportedly used for intermittent disposal of small amounts of liquid wastes. Most recently, in 1991, large volumes of soil contaminated with petroleum hydrocarbons from an unknown source were encountered during excavation operations for Building 306's first floor and foundations. This area will be investigated during the RI for OU-2 (see OU-2 FSAP for details).

It is impossible to estimate the amount of waste that was disposed of in the seepage pits because records were not kept on the types and volumes of materials that were disposed of down sinks, drains, lavatories, etc. The U.S. Army apparently also has no records available of materials allegedly dumped into the seepage pits, storm drains, or temporary pits.

The types of materials used at JPL throughout its history is, to some extent, better known. These materials include a variety of solvents (carbon tetrachloride, methylene chloride, methyl ethyl ketone, trichloroethane, acetone, tetrachloroethane, benzene, etc.), small amounts of solid and liquid rocket propellants, cooling tower chemicals, sulfuric acid, Freon, mercury, alcohols, and various other chemical laboratory substances. All propellants used for testing were expended in concrete test cells where all materials were completely spent during the tests. All unused materials were shipped off-site for destruction.

4.2.7 On-site Receptors Exposure Pathways

Human Receptors and Exposure Pathways

The major potential on-site exposed population is the on-site workers. Although the groundwater beneath the site is not used on the site, the public city water supply seasonally supplements the water used on the site in processing and for drinking water (Ebasco, 1990; Ebasco 1991). The on-site worker may come in contact with contaminated water through:

- Ingestion of drinking water,
- Inhalation of volatilized contaminants in standing process water, and
- Dermal contact during work procedures or hand-washing.

However, because of water treatment prior to its distribution in the Pasadena water system, and the regular check on water quality required by law, the potential for exposure by this pathway is very unlikely. Although this pathway is one that will be carried through the risk assessment it is currently of minimal concern since all City of Pasadena drinking water provided by wells containing these compounds is treated to meet drinking water standards.

The area of exposed on-site surface soil is relatively small compared to the overall area of the JPL site due to the presence of buildings, parking lots, and other paved and concrete-covered areas. In Ebasco's 1990 Supplemental Information for the Expanded Site Investigation, data collected for subsurface waste pit samples indicated that several metals and low levels of total petroleum hydrocarbons (TPH), but no VOCs, were present (Ebasco 1990b). However, if additional data provides information that on-site surface soils are contaminated, then the on-site workers should be evaluated for exposure to contaminated surface soils. The on-site workers may also be exposed to site contamination through inhalation of contaminated particulate soil or volatilized contaminants in surface soils. On-site workers could also be exposed through dermal contact with contaminated surface soils. Trespassers are not an expected exposed population since the site access is effectively restricted. This includes complete fencing with an entry detection system as well as a 24-hour security force.

If waste disposal areas are excavated in the future, then contaminants in the subsurface soil may be released through volatilization or as airborne particulate soil. Therefore, on-site workers may be exposed through inhalation of contaminants released during potential future excavation and if contaminated soils are left exposed at the surface. Detailed discussions of the risk-assessment process are presented in Section 6.0.

Ecological Receptors and Exposure Pathways

The on-site exposure pathways for ecological receptors will be evaluated during the RI/FS. Details are presented in Section 6.0. The area of exposed soil on-site is relatively small compared to the area which is paved and covered by buildings. No surface-soil data has been collected on the site. Detail regarding threatened or endangered species potentially located in the vicinity of the site is discussed in section 4.1.5.

4.2.8 Potential Expedited Response Actions

The possibility exists that during the JPL RI/FS that contaminant conditions are identified where expedited response actions are deemed necessary. These response actions would be needed to:

- Prevent the further migration of contaminants,
- Reduce the risk of human or ecological exposure to the contaminants present, or
- Remove contaminants prior to the construction of new JPL facilities.

The potential expedited response actions would focus on soil or soil vapor in the potential source areas or on groundwater found on the site containing contaminants. There is currently a groundwater treatment system in place to treat groundwater extracted from the four nearby City of Pasadena wells. The response actions for soil or soil vapor could include:

- Soil Removal (excavation),
- Capping of Source Areas,
- Vapor Extraction, or
- Combinations of the above.

The potential response actions for contaminated groundwater could include:

- Installation of a Groundwater Flow Barrier (e.g., slurry walls, sheet piling, and grout curtains),
- Installation of a Groundwater Extraction/Treatment System, or
- Combinations of the above.

Should it be apparent that an expedited response action is needed, NASA will discuss the need with EPA, DTSC, and RWQCB and, if appropriate, develop a formal proposal to implement an expedited response action in accordance with the FFA requirements.

4.2.9 Preliminary Identification Of Operable Units

In evaluating the current data on the nature and extent of constituents of interest in groundwater and historical information on chemical use at JPL (described in Section 5.0), a preliminary identification of three operable units was made. The three operable units and the titles given them are as follows:

- Operable Unit 1 - On-Site Groundwater
- Operable Unit 2 - Potential On-Site Contaminant Source Areas
- Operable Unit 3 - Off-Site Groundwater

Operable Unit 1 (on-site groundwater) is defined as all groundwater underlying and immediately surrounding the JPL facility as shown on Figure 4-18. This coincides with the apparent groundwater mound that is periodically in the Arroyo Seco. The northern boundary is the San Gabriel mountains. The current data indicate that the groundwater underlying this area has been encountered from approximately 30 feet to 270 feet below the ground surface south of the JPL Thrust Fault. The existing conceptual model of groundwater flow within OU-1 is based on water elevations and lithologies encountered in the existing wells. The lithologies encountered indicate that no significant stratigraphic variations occur throughout the unconsolidated alluvial column. As such, there are no identifiable aquitards that would separate different hydrogeologic units. Since there is currently only one hydrogeologic unit below the JPL site, OU-1 will extend from the surface to the crystalline basement.

Operable Unit 2 (potential on-site contaminant source areas) is defined as the soil, waste materials and corresponding unsaturated-zone contamination related to waste discharge existing on the JPL site that have contributed to the contaminated groundwater. A series of potential source areas have been identified during preliminary evaluation of the historical site activities that may have led to the contamination. Several primary areas and secondary areas were identified that may contain waste materials discharged from JPL operations. These locations are described in Section 5.0.

Operable Unit 3 (off-site groundwater) is defined as all contaminated groundwater east and south of the OU-1/OU-3 boundary shown on Figure 4-18. This will be limited to contamination resulting only from releases from the JPL site. The hydrogeology and contamination of OU-3 is currently the least defined of the three operable units. A limited amount of hydrogeologic data on the Arroyo Seco and the Altadena area is available from existing groundwater production wells. Additional information on the stratigraphy and hydrogeology east of this general area will be necessary to fully define the OU-3 boundary. The work planned for OU-3 should provide this information.

JET PROPULSION LABORATORY

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SITE PLAN • FACILITY LOCATIONS

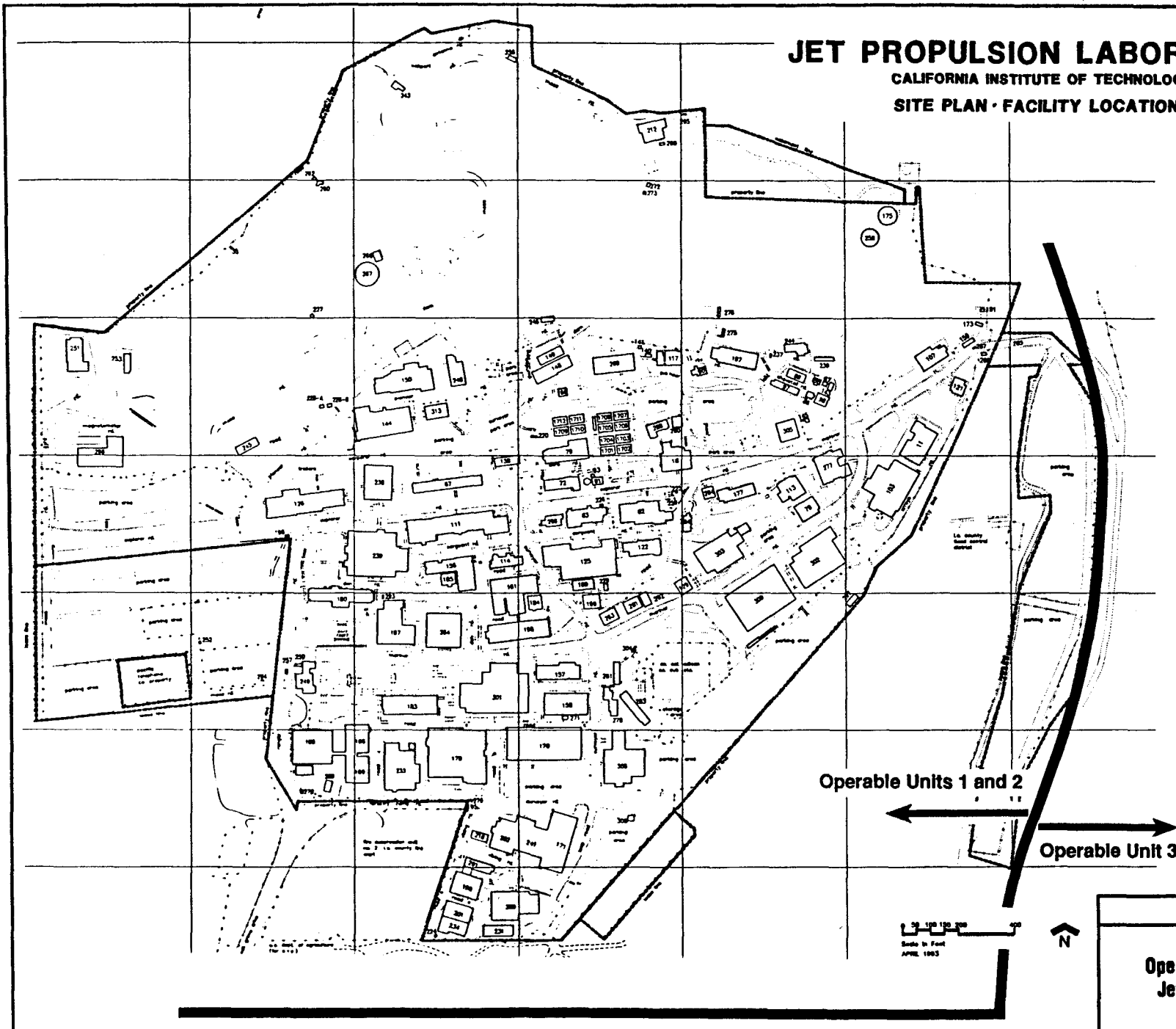


Figure 4 - 18

Operable Unit Boundaries for
Jet Propulsion Laboratory

4.2.10 Preliminary Identification of Remedial Action Objectives and Alternatives

OU-2 - Contaminant Source Identification

Operable Unit 2 (OU-2) consists of the original site(s) where contaminants may have been discharged. The remedial action objective for controlling or removing contaminants from the source area(s) focuses on source control and in minimizing or eliminating future migration of contaminants. Various possible general response actions, and the corresponding remedial technology or technologies for each action are listed in Table 4-2.

TABLE 4-2
SOURCE CONTROL, OU-2

General Response Actions	Technology
No Action	Monitor Groundwater
Containment	Impermeable Caps/Barriers
Excavation and On-Site Treatment	-Vitrification -Solidification -Volatilization (Vacuum Extraction) -Bioremediation
Excavation and Off-Site Disposal	RCRA Landfill
In-Situ Treatment	-Vitrification -Solidification -Volatilization (Vacuum Extraction) -Bioremediation

Inclusion of the No-Action Alternative is required by CERCLA, primarily to facilitate analysis of the cost impacts associated with other technologies. The No-Action scenario provides a baseline cost estimate that can be compared to estimates developed for other response technologies.

OU-1 and OU-3 - Groundwater

Operable Units 1 and 3 (OU-1 and OU-3) include the groundwater under JPL and off-site, respectively. The remedial action objectives for groundwater include migration control by managing groundwater to prevent future exposure to contaminated water and cleanup, if determined necessary. Listed in Table 4-3 are various general response actions, and the corresponding remedial technology or technologies that could meet the remedial objectives.

TABLE 4-3
GROUNDWATER, OU-1 AND OU-3

General Response Actions	Technology
No Action	Monitor Groundwater
Pump and Treat	Air Stripping
	Carbon Adsorption

Inclusion of the No-Action Alternative is required by CERCLA, primarily to facilitate analysis of the cost impacts associated with other technologies. The No-Action scenario provides a baseline cost estimate that can be compared to estimates developed for other technologies.

5.0 SYNOPSIS OF HISTORICAL WORK

Numerous investigations focusing on geotechnical issues and previously identified environmental issues have been conducted at JPL. These investigations range from a seismic study completed to evaluate the earthquake resistance of JPL facilities to the most recent pre-RI explorations, during which several soil borings and groundwater monitoring wells were drilled and soil vapor pilot studies were completed. Presented in the following sections are detailed summaries of previous investigations along with documentation of the field activities and results of the pre-RI program.

5.1 PREVIOUS INVESTIGATIONS

Geotechnical and environmental studies at JPL and in the Arroyo Seco that have been conducted during the past 16 years include the following:

- Agbabian Associates (1977), "Seismic Studies for the Jet Propulsion Facilities, Parts I, II, III."
- LeRoy Crandall and Associates (1981), "Dewatering Well System, Building 150, Jet Propulsion Laboratory, La Canada-Flintridge, California."
- Geotechnical Consultants, Inc. (1982), Untitled set of notes and correspondence concerning drilling and installation of monitoring well MH-01 in the Arroyo Seco for the City of Pasadena.
- Richard C. Slade (1984), "Preliminary Hydrogeologic Assesysment of Soil and Groundwater Monitoring at Jet Propulsion Laboratory, Pasadena, California."
- James M. Montgomery (1986), Untitled letter report outlining hydrogeologic data and contamination as reported by previous investigations.
- Ebasco Environmental (1988a and 1988b), "Preliminary Assessment Report for NASA-Jet Propulsion Laboratory and Site Inspection Report for NASA-Jet Propulsion Laboratory."
- Geotechnical Consultants, Inc. (1989), "Interim Report, Evaluation of Groundwater Quality Upgradient of Jet Propulsion Laboratory, Pasadena, California."
- Ebasco Environmental (1990a), "Expanded Site Inspection Report for NASA-Jet Propulsion Laboratory."
- Ebasco Environmental (1990b), "Supplemental Information to the Expanded Site Inspection Report on the NASA-Jet Propulsion Laboratory."
- Jet Propulsion Laboratory (1990), Untitled set of memoranda, laboratory analyses, notes, sketches, and other correspondence associated with the removal of storm drain catch basin and contaminated soil.
- Seepage Pit Research (1990 to Present)

- Ebasco Environmental (1991), "Remedial Investigation/Feasibility Study Work Plan (draft) for NASA-Jet Propulsion Laboratory."
- Maness Environmental Services, Inc. (1992), "Environmental Site Investigation and Soil Remediation, Jet Propulsion Laboratory, Pasadena, California."
- Ebasco Environmental (1992), "Groundwater Model Selection for NASA-Jet Propulsion Laboratory Site."

Each of these studies are discussed briefly in the sections that follow.

5.1.1 Agbabian Associates (1977)

A three-part seismic study of JPL conducted by Agbabian Associates was completed in 1977. In 1976, a Seismic Safety Plan was prepared for JPL in part to develop a procedure for upgrading the earthquake resistance of the JPL facilities. Part I of Agbabian's study, A Study of Seismic Criteria for the Jet Propulsion Laboratory Facilities, provided a state-of-the-art reappraisal of the seismic input criteria developed in 1972 for this plan. As part of Agbabian's study, geologic, seismologic and soil investigations were completed. The JPL Thrust Fault was reevaluated and remapped. Data from a trench cut across the JPL Thrust Fault at the mouth of the Arroyo during a previous investigation was reexamined. The results of Agbabian Associate's fault study are summarized in Figures 4-10 and 6-1. Data on the subsurface conditions at JPL were also reevaluated. In 1977, LeRoy Crandall and Associates (Crandall, 1977 - a previous report referenced in the Agbabian Associates report) drilled and sampled three borings at locations shown on Figure 5-1 in an effort to estimate the effects that the alluvial-fan materials had on modifying earthquake motions at the site, and to evaluate the potential liquefaction and instability of foundation soils. All three borings were drilled with mud-rotary drilling techniques. Borings 1 and 3 were drilled to 100 feet, and boring 2 was drilled to the granite basement rock at a depth of 680 feet. Boring 2 was subsequently completed to 414 feet with 5-inch-diameter schedule 40 PVC blank casing to allow instruments to be lowered into the hole for a downhole seismic survey.

Part II of Agbabian Associates' study, Supplemental Geologic Studies for the Jet Propulsion Laboratory Facilities, reported on additional investigations subsequent to Part I. These included trenching across the JPL Thrust Fault to locate materials suitable for dating the most recent fault activity. A trench was excavated across the JPL Thrust Fault west of former Building 32 (Figure 5-1). The trench was 36 feet long and had a maximum depth of 12 feet. The JPL Thrust Fault, as exposed along the length of the trench as shown in Figure 5-2, strikes east-west and dips to the north at 24 degrees. A sample of calcium carbonate precipitate, which was interpreted to have been deposited after the last fault movement, was collected from the trench and was isotopically dated to have formed between 800 and 2,000 years ago.

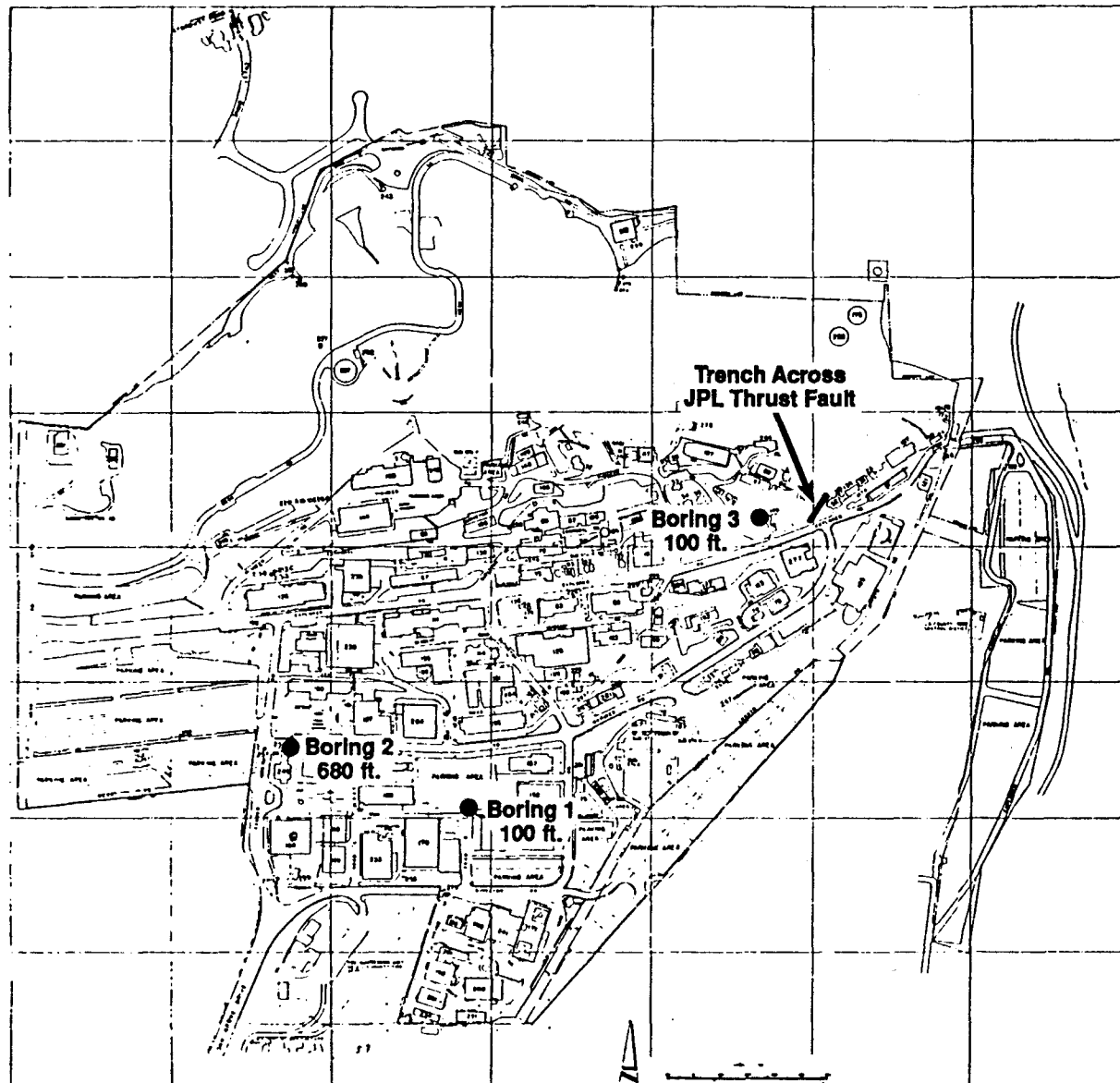


Figure 5 - 1

Soil Boring and Trench Locations
Referenced in Agabian
Associates (1977)

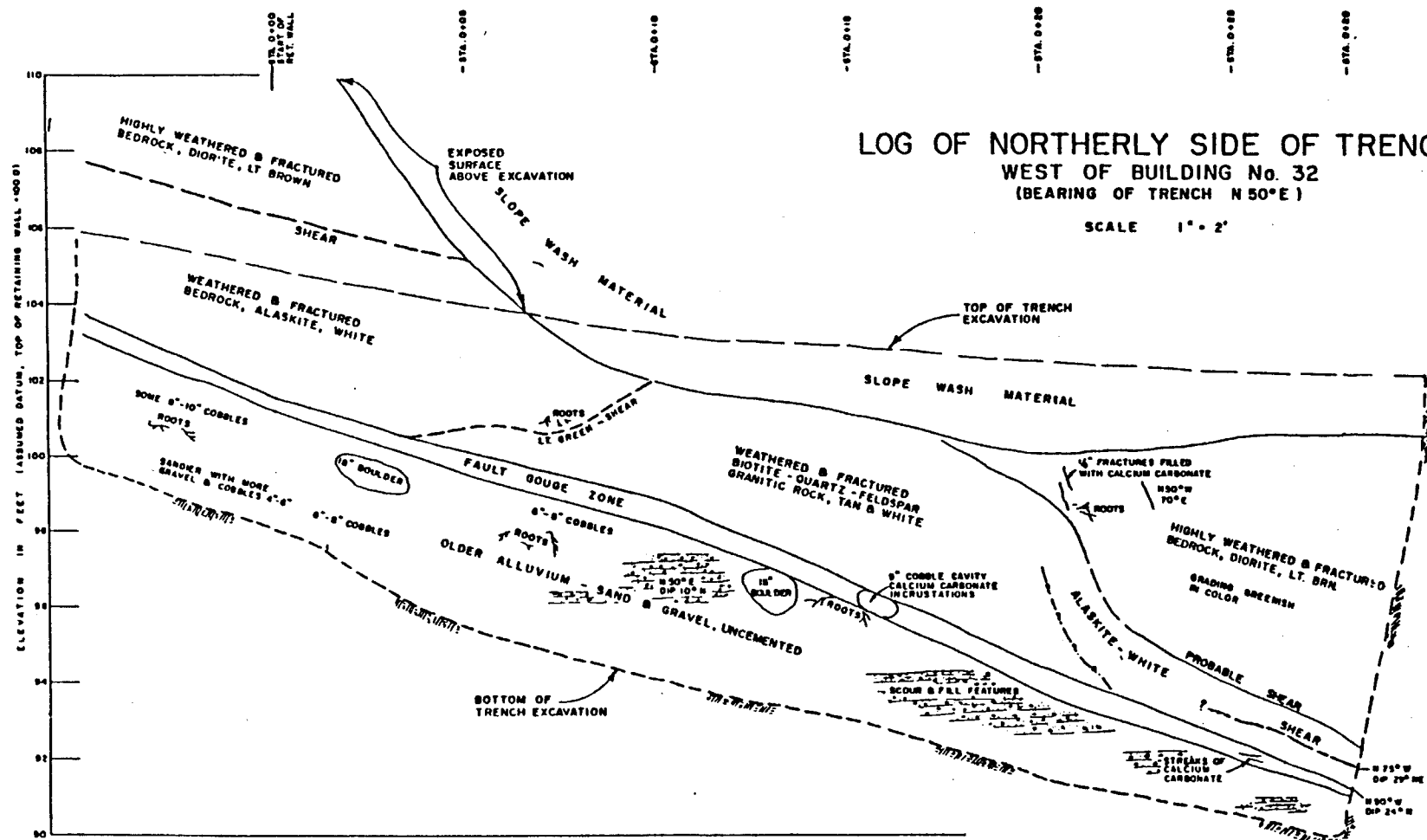


Figure 5-2

Cross-Section of Trench
 Across JPL Thrust Fault

Source: Agabian Associates, 1977.

Part III of Agbabian Associates' study, Implications of Fault Hazard for the Jet Propulsion Laboratory Master Plan, discussed recommendations for the use of existing facilities and for the development of land within a zone of potential earthquake ground breakage on the property.

These studies were originally intended for earthquake and seismic evaluations only and were not conducted for any CERCLA-related effort. However, the results of Agbabian Associates' work allows insight into the geologic structure of the JPL site. This information will be used to help the CERCLA effort in understanding the geologic structure of the site and its potential impact on groundwater flow and containment transport.

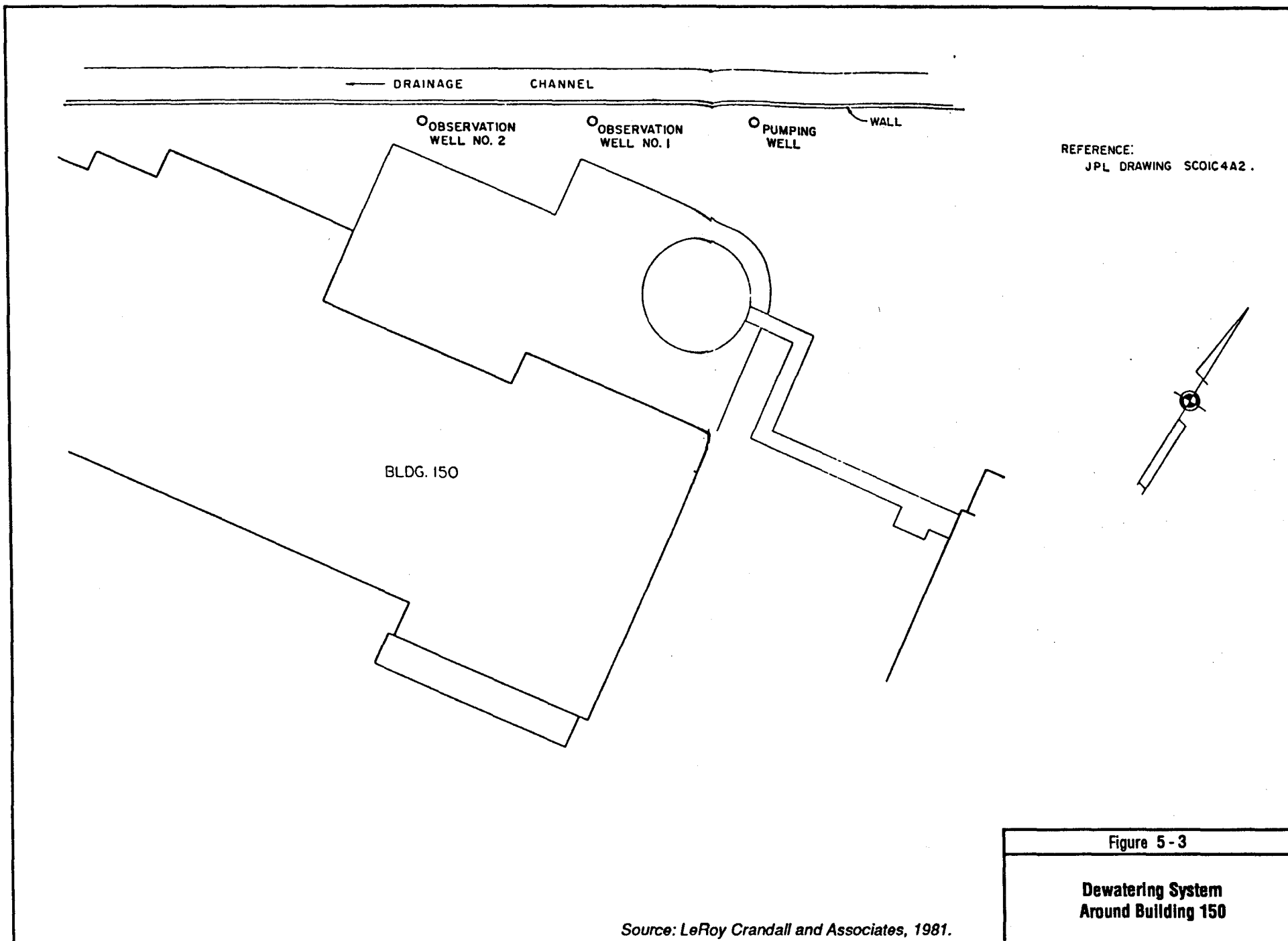
5.1.2 LeRoy Crandall and Associates (1981)

In 1981, LeRoy Crandall and Associates performed an evaluation of a soil dewatering system around Building 150 at JPL. During periods of high precipitation, water was entering the basement of Building 150. Three wells were installed by Barney's Hole Digging Service, Inc. and were logged by a LeRoy Crandall and Associates field geologist.

The dewatering system consisted of one 12-inch-diameter, 60-foot-deep pumping well, and two 4-inch-diameter, 40-foot-deep observation wells installed at distances of 40 feet and 80 feet, respectively, away from the pumping well (Figure 5-3). During drilling of the 60-foot pumping well, crystalline basement rock was encountered at a depth of about 2 feet. Crystalline basement rock was encountered in Observation Well No. 1 at about 15 feet and in Observation Well No. 2 at about 20.5 feet. Above the basement rock, alluvial soils consisting of silty sand and sand with gravel and cobbles were encountered.

Based on a performance record of about 3 months, during which the average pumping rate was about 3.2 gallons per minute, the system appeared to be removing significant quantities of water north of the building. However, the entire area had not been dewatered as indicated by water levels in the observation wells. The water level in Observation Well No. 1, located a distance of 40 feet from the pumping well, had declined 3 feet during this period of time, and the water level in Observation Well No. 2, located 80 feet from the pumping well, had declined less than 0.5 feet.

Recommendations made by LeRoy Crandall and Associates included modifying the operation of the pumping well to increase its area of influence and converting the observation wells into pumping wells.



Here again, this study was conducted for purposes other than CERCLA. The information is useful to the CERCLA effort as it provides insight on the groundwater and geologic structure of the site north of the JPL Thrust Fault.

5.1.3 Geotechnical Consultants, Inc. (1982)

In 1982, Geotechnical Consultants, Inc. (GCI) conducted a preliminary hydrologic assessment of potential volatile organic contamination in the groundwater in the Arroyo Seco for the City of Pasadena. This investigation included the installation of a groundwater monitoring well, groundwater sampling, and chemical analysis of water samples. A final report was not submitted to the City of Pasadena because the appropriated budget had been exceeded before the project was completed. Ebasco obtained information on this investigation from a City of Pasadena Water and Power Department open file.

The GCI investigation included the drilling of monitoring well MH-01 to a depth of 399 feet in the Arroyo Seco approximately halfway between one of Pasadena's water supply wells (Arroyo Well) and JPL Building 103. It was believed that the source of the volatile organic contamination in the Arroyo Well was a former waste disposal pit located near JPL Building 103. A 9 7/8-inch-diameter boring was cased to a depth of 366 feet with 6-inch-diameter PVC blank casing and slotted PVC casing. The well was screened at nine different intervals between the depths of 145 feet and 355 feet. A sandpack was placed continuously in the well's annulus from 366 feet to approximately 100 feet below ground surface without any seals between the screened intervals.

Standard decontamination procedures were employed to minimize contamination from the well-construction materials and the drilling and sampling equipment. Soil and groundwater samples were collected from different depths in the boring and the well, respectively. Water samples were collected using syringes and by pumping. Samples were analyzed by Montgomery Laboratories for volatile organics, trihalomethanes/synthetic organics, pesticides, PCBs, and herbicides. Analytical results for the water samples indicated that concentrations of carbon tetrachloride (CCl_4), trichloroethene (TCE), and tetrachloroethene (PCE) were present above drinking water standards. The reported concentrations of CCl_4 , TCE, and PCE are summarized in Table 5-1. Pesticides, herbicides and PCBs were not detected.

The report by GCI provided the first evidence that volatile organic compounds (VOCs) were present in the groundwater in the Arroyo Seco. This effort was not performed in response to CERCLA, but began to provide information regarding possible containment transport. During the RI, soil vapor samples will be analyzed and at least one soil boring will be drilled and

TABLE 5-1**SUMMARY OF CCl₄, TCE, AND PCE CONCENTRATIONS IN GROUNDWATER
SAMPLES FROM MONITORING WELL MH-01**

Sampling Date	Sampling Depth (feet)	Carbon tetrachloride (µg/l)	Trichloroethene (µg/l)	Tetrachloroethene (µg/l)
12-16-82	359	22	36	1.8
	359	14	38	1.9
12-17-82	212	0.8	2.9	0.4
	212	1.3	4.7	0.5
12-21-82	191	1.2	4.4	0.5
	233	1.6	7.7	0.6
	264	7.5	37	2.0
	306	17	59	2.3
	192	1.4	5.2	0.6
	234	2.2	7.6	0.8
	265	7.5	34	2.2
	307	12	42	1.9
12-23-82	182	ND	ND	0.1
	192	ND	ND	0.1
	218	ND	0.3	0.2
	234	0.6	2.2	0.4
	265	7.9	35	2.2
	288	16	50	2.5
	307	16	49	2.5
	352	14	44	2.1

ND - Not detected at minimum detection limit of 0.1 µg/l.

Reference: Geotechnical Consultants, Inc., 1982.

sampled in the area where the alleged waste disposal pit (Figure 6-1, WP-1) was located south of Building 103.

5.1.4 Richard C. Slade (1984)

A preliminary assessment of soils and groundwater at JPL was prepared by Richard C. Slade in 1984. The purpose of this report was to provide a preliminary hydrogeologic assessment of the quantitative results of laboratory data generated from testing soil and water samples collected on or near JPL.

This investigation involved the excavation of exploration trenches at two abandoned seepage pits (cesspools) at JPL and groundwater sampling from City of Pasadena monitoring well MH-01. The cesspools investigated were located southwest of former Building 59 (Seepage Pit No. 16) and southwest of former Building 65 (Seepage Pit No. 13). Both buildings previously housed chemistry laboratories.

Exploration of these former seepage pits consisted of digging three to four trenches at each site, logging the trenches and collecting soil samples for laboratory analysis. The trenches ranged in depth from 8 to 13 feet and were excavated using a backhoe equipped with a 2-foot-wide bucket. None of the trenches were excavated to the bottom of the seepage pits. Soil samples were collected from depths ranging from 1 to 9.5 feet. Relatively undisturbed samples were obtained from the in-place materials exposed in the trench by driving a 0.01-cubic-foot brass sampling sleeve into the soil and immediately capping both ends of the sleeve. These samples were analyzed for CCl_4 , TCE, PCE, and 1,1,1-trichloroethane (TCA). Analyses for priority pollutant metals, fluoride, and pH were conducted on both undisturbed and bulk soil samples.

Laboratory analyses on undisturbed soil samples collected from the trenches did not detect any volatile organic compounds. Lead was detected in a concentration of about 200 parts per million (ppm) at a depth of 7 feet at the location of Seepage Pit No. 16 that served Building 59. The source of this lead was not determined.

The groundwater investigation included collecting water samples from the nine different screened intervals in monitoring well MH-01. The report noted that the well was not purged before sampling. Laboratory water-quality tests conducted on each of the samples included analyses for metals, fluoride, cyanide, hexane, TCE, PCE, CCl_4 , and 1,1,1-TCA.

Laboratory results of water samples collected from well MH-01 indicated some metals were present in concentrations below State of California maximum contaminant levels (MCLs) for drinking water. Mercury was present in the sample collected from the 182-foot depth in a

concentration above its MCL. Fluoride was present at concentrations of 13 and 14 milligrams per liter (mg/l) in samples collected from depths of 234 feet and 265 feet, respectively. Fluoride concentrations in all the other water samples were below the MCL of 1.8 mg/l. PCE was found in all samples and ranged in concentration from 0.2 to 0.7 micrograms per liter ($\mu\text{g/l}$). TCE and CCl_4 were found only in samples collected below 265 feet. Reported concentrations of TCE ranged from 1.3 to 7.5 $\mu\text{g/l}$ and concentrations of CCl_4 ranged from 0.2 to 2.4 $\mu\text{g/l}$. Results of the organic and inorganic analyzer performed on the groundwater samples are presented in Tables 5-2 and 5-3.

The Slade Report was not directly tied to the CERCLA effort, but it did provide valuable information on two of the potential source locations and additional laboratory analyses of groundwater samples collected from monitoring well MH-01.

5.1.5 James M. Montgomery (1986)

During 1986, James M. Montgomery conducted an evaluation of contaminant transport of volatile organic compounds (VOC) in the groundwater in the Arroyo Seco for the City of Pasadena. The objectives of this evaluation were to estimate the following:

- Location of the source of contamination.
- Rate and direction of contaminant plume movement.
- Maximum Expected Contaminant Levels (MECLs) that might be anticipated in the contaminated wells.

Montgomery relied upon data collected previously by either the City of Pasadena Water and Power Department or by the Regional Water Quality Control Board. Their analyses were based on parameter analyses whereby the potential effects of variations in aquifer parameters on the concentrations and locations of contaminant plumes are evaluated to estimate groundwater flow velocities and dispersion coefficients.

The parameter analyses were conducted using an analytical one-dimensional dispersion model that assumes no molecular diffusion. The primary transport mechanism is assumed to be hydrodynamic dispersion (coupled groundwater flow velocity and dispersion).

The one-dimensioned dispersion model used by Montgomery required the input of an average groundwater velocity and a dispersion coefficient for calculating relative concentrations at some distance from a potential source at a given period of time. Groundwater velocities and hydraulic conductivities were estimated based on calculated transmissivities for various municipal wells

TABLE 5-2

**SUMMARY OF ANALYTICAL RESULTS FOR INORGANIC COMPOUNDS IN
GROUNDWATER SAMPLES FROM MONITORING WELL MH-01**

Sample depth (Feet)	Metals (Concentrations in mg/l)												Others (Conc. in mg/l)		
	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn	Fluoride	Cyanide
155	ND	ND	ND	0.004	ND	0.008	0.0013	ND	0.014	ND	ND	ND	ND	0.53	ND
182	ND	ND	ND	0.004	ND	ND	0.0022	ND	0.017	ND	ND	ND	ND	0.55	ND
192	ND	ND	ND	ND	ND	ND	ND	ND	0.019	ND	ND	ND	ND	0.5	ND
218	ND	ND	ND	0.004	ND	ND	0.0004	ND	0.021	ND	ND	ND	ND	0.54	ND
234	ND	ND	ND	0.005	ND	ND	ND	ND	ND	0.002	ND	ND	0.007	13	ND
265	ND	ND	ND	0.006	ND	ND	0.0005	ND	ND	ND	ND	ND	ND	14	ND
288	ND	ND	ND	0.004	ND	ND	0.0012	ND	0.002	ND	ND	ND	0.01	0.79	ND
307	ND	ND	ND	0.003	ND	ND	ND	ND	0.002	ND	ND	ND	ND	0.58	ND
352	ND	ND	ND	0.006	ND	0.011	0.0006	ND	0.005	0.003	ND	ND	ND	0.66	ND
MCL:	0.05	0.05	—	0.01	0.05	1.0	0.002	—	0.05	—	0.01	—	5.0	1.8	NR
DL:	0.005	0.001	0.004	0.003	0.029	0.007	0.0002	0.008	0.002	0.002	0.001	0.005	0.007	NR	0.005

mg/l - milligrams per liter.

ND - Not detected.

MCL - Maximum contaminant level.

DL - Detection limit.

NR - Not reported.

Reference: Richard C. Slade, 1984.

TABLE 5-3**SUMMARY OF ANALYTICAL RESULTS FOR ORGANIC COMPOUNDS IN GROUNDWATER
SAMPLES FROM MONITORING WELL MH-01**

Sample Depth (feet)	Hexane ($\mu\text{g/l}$)	Trichloroethene ($\mu\text{g/l}$)	1,1,1- Trichloroethane ($\mu\text{g/l}$)	Tetrachloroethene ($\mu\text{g/l}$)	Carbon tetrachloride ($\mu\text{g/l}$)
155	ND	ND	ND	0.7	ND
182	ND	ND	ND	0.3	ND
192	ND	ND	ND	0.6	ND
218	ND	ND	ND	0.3	ND
234	ND	ND	ND	0.3	ND
265	ND	1.3	ND	0.3	0.2
288	ND	3.5	ND	0.4	1.1
307	ND	2.9	ND	0.2	0.8
352	ND	7.5	ND	0.3	2.4

$\mu\text{g/l}$ - micrograms per liter.

ND - Not detected at minimum detection limit of 0.1 $\mu\text{g/l}$.

Reference: Richard C. Slade, 1984

in the area, and longitudinal dispersion coefficients were estimated based on Montgomery's experience and previous studies in areas having similar subsurface geologic conditions.

It was concluded that the contamination in the City of Pasadena Arroyo Well appeared to originate from a source located north-northwest of the well. Based on review of JPL's history, measured VOC concentrations in the groundwater samples, the estimated parameters summarized above, and estimated source distances from the well, Montgomery concluded that the VOCs were from a source that originated less than 5,000 feet from the Arroyo Well.

To permit estimated predictions of MECLs, the locations of contaminant sources and a detailed understanding of the subsurface hydrogeology was needed. This information was not available to Montgomery for their study, and, therefore, MECL predictions were based on estimated source durations, groundwater flow velocities, and dispersion coefficients. The predictions suggested that MECLs for VOCs of about 170 $\mu\text{g/l}$ could be expected at the City of Pasadena Arroyo Well if current (1986) trends continued. They noted, however, that depending upon the precise location and strength of the contaminant source, higher concentrations could be observed.

Review of pumping records from water production wells in or near the Arroyo Seco, together with rainfall data, suggested that pumping of the City of Pasadena Arroyo Well was perhaps preventing contaminants migrating to the south and southeast of the well.

This report was not done for CERCLA, but did provide some information regarding the potential for contaminants to reach the City of Pasadena municipal wells. The report was of limited value because of the numerous assumptions made. Information from this report did not make a substantial contribution to subsequent reports.

5.1.6 Ebasco Services Incorporated (1988a and 1988b)

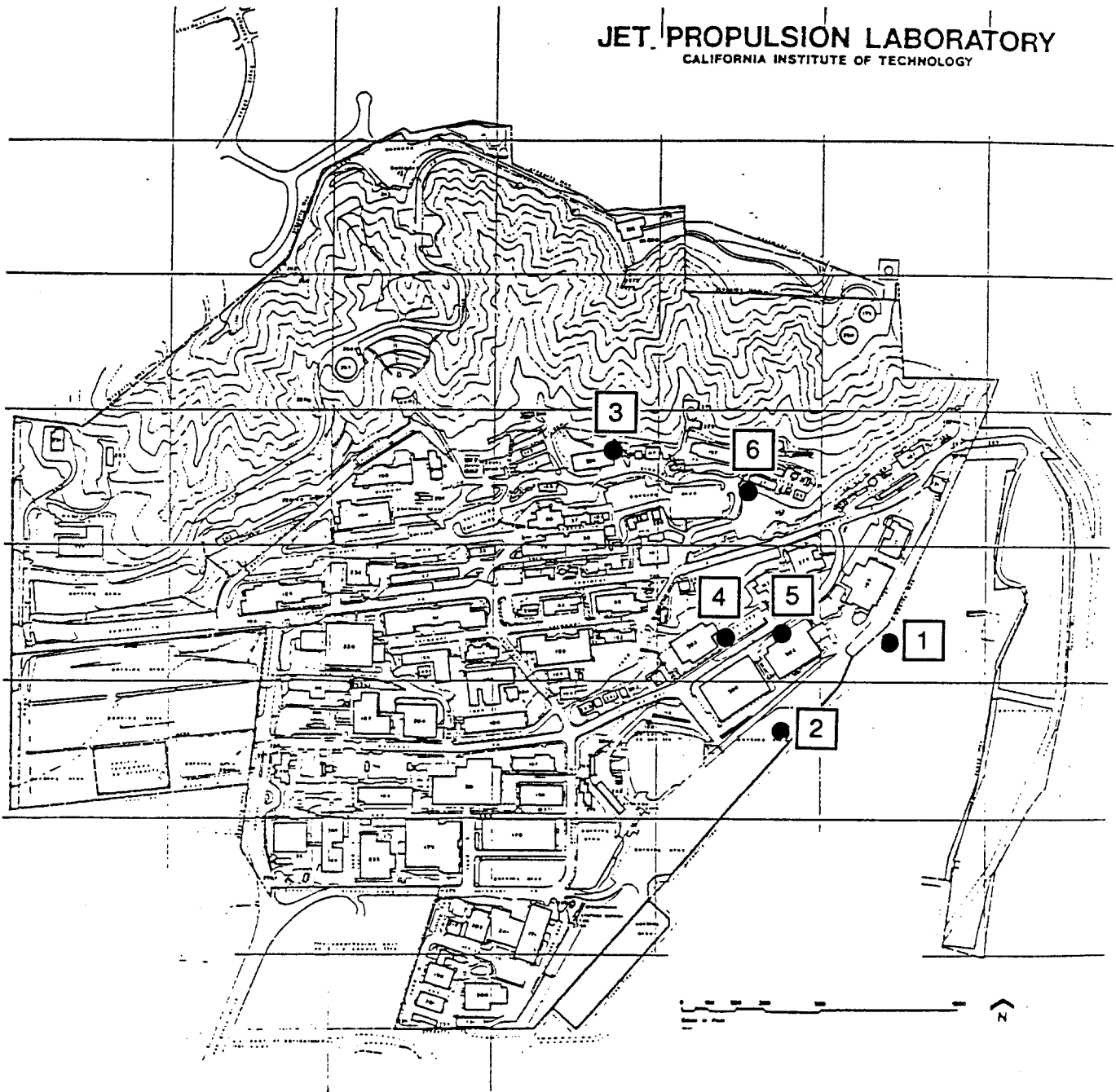
A Preliminary Assessment (PA) and a Site Inspection (SI), as mandated by CERCLA, was performed at JPL in 1988 (Ebasco 1988a and 1988b). During the PA, potential areas of concern were identified that included abandoned solid waste disposal pits, seepage pits (cesspools), past chemical spills, and VOC contamination in three City of Pasadena municipal water supply wells located downgradient from the JPL site. These concerns were evaluated through interviews, a literature review, and a reconnaissance of the alleged waste-disposal and chemical-spill areas during the SI activities. The purpose of the PA and SI was to obtain the necessary information for computing the Hazard Ranking System (HRS) score. Neither subsurface explorations nor analytical work was conducted during the PA and SI activities.

Six pits or old waste disposal sites on and adjacent to JPL property (Figure 5-4) were discussed in the PA and SI reports. Based on information available at the time the PA and SI reports were prepared, it was reported that the pits ranged from 5 to 30 feet wide and 15 to 30 feet deep, and were used between 1945 and 1960 for disposal of municipal wastes, and solid and liquid hazardous wastes. Erroneously, all six pits were denoted as seepage pits in the PA and SI reports when, in fact, only two were actual seepage pits (cesspools). These two pits were investigated by Richard C. Slade in 1984 (discussed previously in Section 5.1.4), and only a lead concentration of about 200 ppm was found in the soil near one of these pits (Pit 4) at that time.

Below is a summary of each of the pits, or waste disposal sites, as discussed in the PA and SI reports, although information obtained subsequently disputes some of these earlier conclusions.

- Seepage Pit 1 (Waste disposal area now designated as WP-1): Believed to be located near Building 103 (Figure 5-4, 1) outside of the JPL property line in the Arroyo Seco dry wash (see Section 5.1.11) and is not associated with any JPL building. This area was approximately 15 feet in diameter, of unknown depth, and was used primarily for disposal of municipal solid wastes. However, according to available information, chemical wastes were also disposed here including solvents, freon, mercury, liquid and solid rocket propellants, cooling tower chemicals, and sulfuric acid. Other information indicated that the pit was not used for disposing liquid wastes. Sampling of this pit had not been conducted prior to this study.
- Seepage Pit 2 (Solid waste disposal area now designated as WP-2): Believed to be located in the south parking lot (Figure 5-4, 2) south of Buildings 300 and 302. This pit was approximately 30 feet wide and 15 feet deep. Wastes disposed at this pit were reported to be similar to those disposed of at Pit 1. The site was also used for burning debris and for disposal of fluorescent lights and scrap magnesium. Sampling of this pit had not been conducted prior to this study.
- Seepage Pit 3 (Now designated as Seepage Pit No. 28): Located north of former Building 77 and beneath the existing Building 299 (Figure 5-4, 3). The pit was approximately 5 feet in diameter and about 30 feet deep, and was reportedly used primarily for the disposal of propellants and mixed solvents. (This pit was initially designed to receive exhaust gases from an experimental propulsion system that used fluorine gas as a propellant). It was also reportedly used primarily for the disposal of propellants and mixed solvents. No sampling of this pit had been conducted prior to this study.
- Seepage Pit 4 (Now designated as Seepage Pit No. 16): Located near Building 303 and previously used for disposal of liquid wastes from former Building 59 (Figure 5-4, 4). This pit was apparently used for the disposal of chemistry lab wastes. This pit location was investigated down to a depth of 11 feet in 1984 by Richard C. Slade (Slade, 1984). Lead in a concentration of about 200 ppm was found in the soil at depth of 7 feet. No other contaminants were found.
- Seepage Pit 5 (Now designated as Seepage Pit No. 13): Located near Building 302 and previously used for disposal of liquid wastes from former Building 65

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LEGEND

- Suspected Seepage Pits used for Waste Disposal (approximate Locations)

References: Ebasco 1988a and 1988b.

Figure 5-4

**Suspected Seepage Pit Locations
as Identified in the
Preliminary Assessment and
Site Inspection Reports**

(Figure 5-4, 5). This pit was also apparently used for the disposal of chemistry lab wastes. Richard C. Slade also investigated this pit in 1984 (Slade, 1984) and did not find any contaminants in the soil down to a depth of 9.5 feet.

- Seepage Pit 6 (Background soil-sample location): Located near Building 97 on a previous natural slope (Figure 5-4, 6). This location was initially believed to be near a former chemistry lab that used this area for disposal of lab wastes. (This area was selected by Richard C. Slade for obtaining uncontaminated soil samples so that chemical analyses results could be compared with those associated with Buildings 59 and 65.) Slade investigated this area down to 11 feet and no contaminants above background levels were detected (Slade, 1984).

The information obtained and reviewed during the PA and SI was used to calculate an unofficial Hazard Ranking System (HRS) score for JPL. Therefore, the PA and SI were the first "official" documents prepared for the CERCLA process. The resulting preliminary HRS score was 38.3, using the unrevised EPA method of calculation. This was above the 28.5 criteria required in the past for a site to be considered for inclusion on the National Priorities List (NPL).

These reports were required by CERCLA. The study was a review of potential sources only. No analytical work (lab work) was completed. Along with a preliminary HRS score, these reports provided valuable information in the form of insight into the source types and locations. This information served as the basis of extensive additional source research.

5.1.7 Geotechnical Consultants, Inc. (1989)

An evaluation of groundwater quality upgradient of JPL was conducted by Geotechnical Consultants, Inc. (GCI) for MARMAC and the U.S. Army Corps of Engineers in 1989. The purpose of this investigation was to install two groundwater monitoring wells upgradient and outside the influence of JPL facility activities. These wells were to be sampled and water-quality analyses were to be performed to establish background water-quality data for JPL.

Monitoring well CMW-1 (now designated as MW-1) was installed just outside the northeast corner of JPL's property and monitoring well CMW-2 (now designated as MW-2) was installed in the southwest corner of the west parking lot at JPL. Both wells were drilled with mud-rotary techniques. Well MW-1 was drilled to 162 feet and well MW-2 was drilled to 179 feet. The depth to the groundwater, based on geophysical log interpretation, was estimated to be 85 feet below grade in well MW-1 and 140 feet below grade in well MW-2. Forty feet of well screen was subsequently installed from 70 to 110 feet in well MW-1 and from 129 to 169 feet in well MW-2. After well-development procedures were completed in each well, the water level in well MW-1 was measured at 39 feet below grade and well MW-2 was found to be above the water

table. Well MW-2 was not drilled deeper owing to contractual limitations. Boring logs and well-completion details for MW-1 and MW-2 are presented in Appendix B.

Groundwater samples were collected from well MW-1 and from existing downgradient City of Pasadena monitoring well MH-01. Water samples from both wells were analyzed for volatile and semi-volatile organics, total petroleum hydrocarbons, five target metals (total and dissolved arsenic, lead, mercury, selenium, and silver), pH, and total dissolved solids. Laboratory results revealed no evidence of organic contamination and no elevated levels of the five target metals in either well. A summary of the laboratory results is listed in Table 5-4.

It was concluded in the report that MW-1 was a legitimate upgradient sampling point to JPL and that there is no immediate evidence of groundwater contamination entering the northeast part of the study area along the Arroyo Seco.

The report prepared by GCI includes valuable input to the CERCLA effort by providing upgradient wells for future use. These wells are included as part of the analyses for most subsequent reports.

5.1.8 Ebasco Environmental (1990a)

From January to March 1990, an Expanded Site Inspection (ESI) was conducted at JPL (Ebasco, 1990a). The objectives of the ESI were to obtain additional information on potential contaminants in the groundwater and soils at JPL by installing a limited number of groundwater monitoring wells and conducting soil gas surveys at suspected waste disposal sites identified in previous investigations (Slade, 1984; Montgomery, 1986; Ebasco, 1988a and 1988b). During the ESI, five groundwater monitoring wells were installed at the locations shown in Figure 5-5, and 38 passive soil-gas collectors were used to obtain preliminary data on the extent of chemical components in groundwater and soil. These data were collected to provide additional support and documentation for the EPA to provide a final Hazard Ranking System (HRS) score for JPL.

Groundwater Monitoring Wells

The monitoring wells were located to obtain water-quality information on groundwater near locations where previous waste-disposal activities reportedly occurred, and to obtain groundwater elevations so that gradients and directions of flow could be identified.

Two of the monitoring wells (MW-3 and MW-4) were drilled to crystalline basement rock, as deep as 730 feet below ground surface, with mud-rotary drilling equipment. Both of these deep monitoring wells were completed with multi-port (MP) casing systems, designed by Westbay

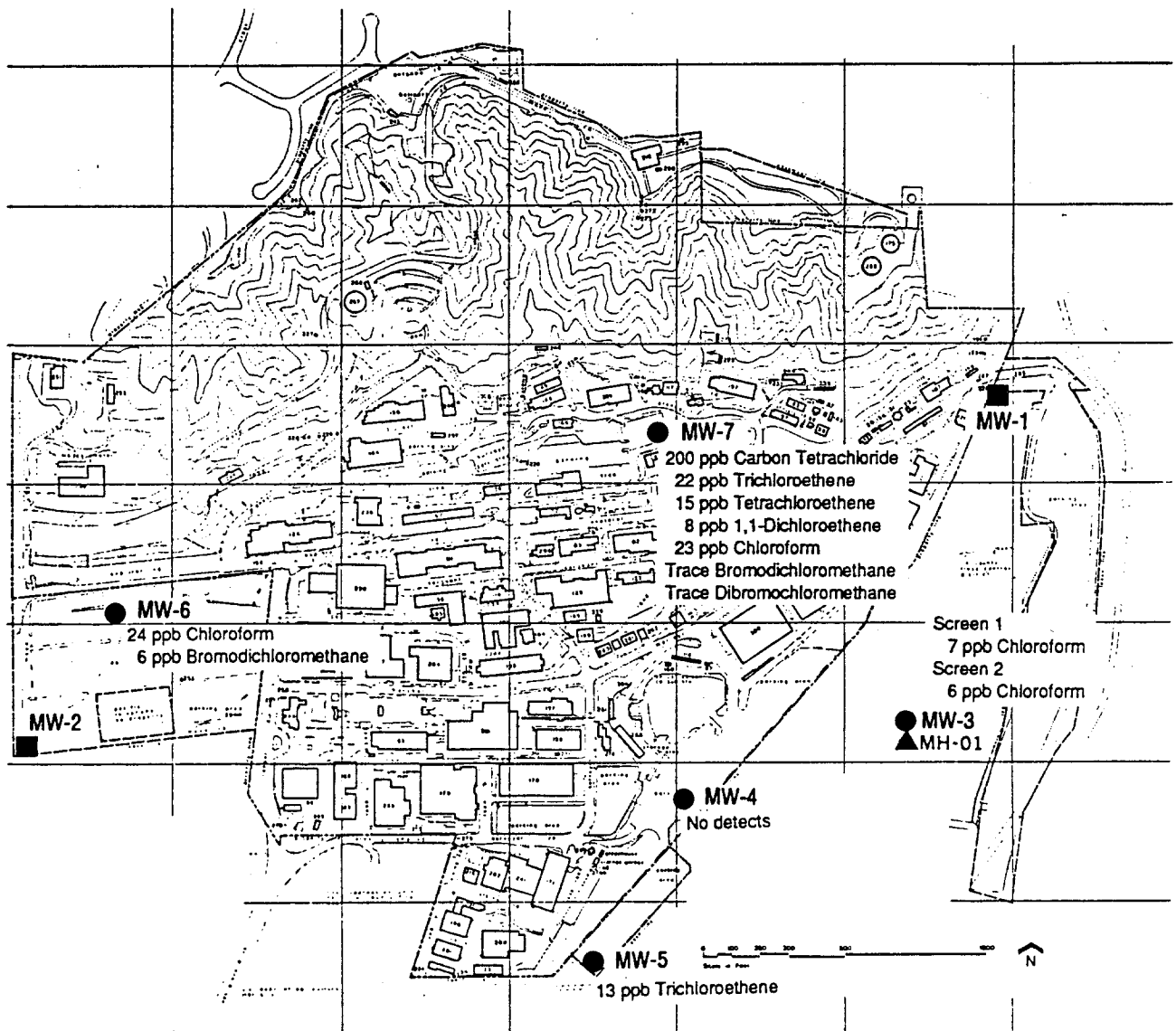
TABLE 5-4**SUMMARY OF ANALYTICAL RESULTS FOR GROUNDWATER SAMPLES
FROM MONITORING WELLS MW-1 AND MH-01**

Parameter	Well MW-1	Well MH-01	EPA Method
Semi-volatile organic compounds	None	None	625
Total petroleum hydrocarbons	None	None	418.1
Metal, total (mg/l)			
Arsenic	<0.005	<0.005	SM 207A
Lead	<0.05	<0.05	239.1
Mercury	<0.001	<0.001	245.1
Selenium	<0.005	<0.005	SM 323A
Silver	<0.015	0.049	272.1
Metals, dissolved (mg/l)			
Arsenic	<0.005	<0.005	SM 307A
Lead	<0.05	<0.05	239.1
Mercury	<0.001	<0.001	245.1
Selenium	<0.005	<0.005	SM 323A
Silver	<0.015	<0.015	272.1
pH	7.6	7.6	150.1
Total dissolved solids (mg/l)	344	305	160.1
Specific conductance (μ mhos/cm)	518	435	NR

mg/l: Milligrams per liter.

μ mhos: Micromohs per centimeter.

NR: Not reported.



Legend:

● Installed during ESI investigation

■ Installed by Geotechnical Consultants, Inc. in 1989

▲ Installed by Geotechnical Consultants, Inc. in 1982.

Figure 5 - 5

Locations of Monitoring Wells Installed and Volatile Organic Compounds Detected During the ESI of JPL

Instruments Ltd., which allow for the monitoring and sampling of five separate screened intervals within the aquifer from a single casing system in each well.

Three shallow monitoring wells (MW-5, MW-6, and MW-7), ranging from depths from 140 to 275 feet, were drilled with a dual-wall percussion drilling rig using reverse-air circulation and were completed as standpipe wells with 50 feet of screen at the bottom of each well. Total depth of each well was determined in the field based on the location of the water table at the particular location.

Construction details for the five monitoring wells installed during the ESI are summarized in Table 5-5. Boring logs and well completion logs for these monitoring wells are presented in Appendix B and the geophysical logs are in Appendix C.

Following the installation and development of the monitoring wells, groundwater samples were collected from each screened interval in the deep wells and from each shallow well. These samples were analyzed for volatile organics (EPA Method 624), semi-volatile organics (EPA Method 625), California Code of Regulations Title 22 metals plus strontium (EPA Method 6010/7000 series), pesticides and PCBs (EPA Method 608), total petroleum hydrocarbons (EPA Method 418.1) and cyanide (EPA Method 9010).

Results of laboratory analyses indicated that the groundwater at JPL contains volatile organic compounds including CCl_4 , TCE, PCE, and 1,1-dichloroethene (1,1-DCE) at concentrations above state and Federal regulatory thresholds for drinking water. Low levels (below regulatory thresholds) of chloroform, bromodichloromethane, and dibromochloromethane (all trihalomethanes) were also detected in the groundwater at JPL but were also present in the QA/QC water samples collected from the fire-hydrant system at JPL. Water from the fire hydrants at JPL was used during field operations (mixing drilling mud, etc.) and is the likely source of the trihalomethanes detected in the groundwater samples. Volatile and semi-volatile organic compounds detected in groundwater samples collected from the monitoring wells during the ESI are summarized in Table 5-6.

Cyanide, organochlorine pesticides, and PCBs were not detected in any water sample collected at JPL. The analytical results indicated that metals including antimony, barium, chromium, cobalt, copper, lead, molybdenum, nickel, zinc, and strontium are present in the groundwater of JPL in concentrations well below state regulatory thresholds established for drinking water. Concentrations of metals and TPH detected in groundwater samples from the five monitoring wells are summarized in Table 5-7.

TABLE 5-5

SUMMARY OF CONSTRUCTION DETAILS FOR MONITORING WELLS INSTALLED AT JPL DURING THE ESI

Well Number	Location	Drilling Method	Total Drilled Depth (feet)	Depth to Bottom of Casing (feet)	Hole Diameter (inches)	Surface Conductor	Elevation Top of Casing (feet above mean sea level)	Screen Interval Below Ground Surface (feet)	Multi-port Well Screen Number
MW-3 (Deep Multi-port Well)	Arroyo Seco	Mud Rotary	730	700	9-7/8	22'; 10"-diameter	1099.82	170-180	1
								250-260	2
								344-354	3
								555-565	4
								650-666	5
MW-4 (Deep Multi-port Well)	JPL South Parking Lot	Mud Rotary	605	559	12-1/4	18.5'; 16"-diameter	1082.72	145-157	1
								237-247	2
								318-328	3
								389-399	4
								509-519	5
MW-5 (Shallow Standpipe Well)	JPL South Parking Lot	Air Percussion Hammer	145	140	11	None	1071.60	85-135	-
MW-6 (Shallow Standpipe Well)	JPL West Parking Lot	Air Percussion Hammer	247	245	11	None	1188.46	195-245	-
MW-7 (Shallow Standpipe Well)	JPL Parking Lot Near Buildings 288 and 290	Air Percussion Hammer	276	275	11	None	1212.90	225-275	-

TABLE 5-6

**SUMMARY OF VOLATILE AND SEMI-VOLATILE ORGANIC COMPOUNDS
DETECTED IN GROUNDWATER SAMPLES**

Analyte	Sample Location (concentrations in µg/l)								Regulatory Threshold ^a	
Well No.: Screen No.:	MW-3 1	MW-3 1 Dup ^b	MW-3 2	MW-5 Dup	MW-5 Dup	MW-6	MW-7	Fire Hydrant Used For MW-4 and MW-5	Fire Hydrant Used For MW-6	
Volatile Organics:										
Carbon tetrachloride	-	-	-	-	-	-	200	-	-	0.5
Tetrachloroethene	-	-	-	-	-	-	15	-	-	5
Trichloroethene	-	-	-	13	13	-	22	-	-	5
1,1-Dichloroethene	-	-	-	-	-	-	8	-	-	6
Chloroform	7	8	6	-	-	24	23	34	36	c
Bromodichloromethane	-	-	-	-	-	6	<5	16	16	c
Dibromochloromethane	-	-	-	-	-	-	<5	13	13	c
Bromoform	-	-	-	-	-	-	-	<5	<5	c
Semi-volatile organic:										
Bis(2-ethylhexyl) phthalate	-	-	17 ^d	-	-	-	-	-	-	NR

^aCalifornia Code of Regulations Title 22 maximum contaminant levels for drinking water.

^bDuplicate.

^cTotal trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform) over 100 µg/l.

^dDetermined to be laboratory contamination.

-: Not detected.

NR - Not regulated.

TABLE 5-7

**SUMMARY OF METALS AND TOTAL PETROLEUM HYDROCARBONS
DETECTED IN GROUNDWATER SAMPLES**

Analyte	Sample Location (concentrations in mg/l)															Regulatory Threshold ^a	
	Well No.: Screen No.:	MW-3 1	MW-3 1 Dup ^b	MW-3 2	MW-3 3	MW-3 4	MW-3 5	MW-4 1	MW-4 1 Dup ^b	MW-4 2	MW-4 3	MW-4 4	MW-4 5	MW-5	MW-6		MW-7
Antimony	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.008	-	0.006 ^c
Barium	0.04	0.04	0.03	0.02	0.04	0.02	0.05	0.05	-	0.03	0.02	0.04	0.05	0.02	0.03	1.0	
Chromium (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.05	
Cobalt	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-	-	NR	
Copper	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	0.02	1.0 ^c	
Lead	-	-	-	-	-	-	-	-	-	-	-	-	0.0045	-	-	0.05	
Molybdenum	-	-	-	0.02	0.02	0.04	-	-	-	-	0.01	0.02	-	-	-	NR	
Nickel	0.10	-	-	-	-	-	-	-	0.01	-	-	-	0.02	-	-	0.1 ^c	
Zinc	-	0.10	0.03	0.02	0.06	0.20	0.06	0.03	0.04	0.11	0.02	0.01	0.23	0.13	0.25	5.0 ^c	
Strontium	0.53	0.60	0.43	0.21	0.43	0.18	0.42	0.45	0.54	0.27	0.30	0.40	0.50	0.66	0.32	NR	
Total petroleum hydrocarbons	-	-	-	-	0.5	0.4	-	-	-	-	-	0.5	0.5	2.0	1.1	NR	

^aCalifornia Code of Regulations EPA Title 22 maximum contaminant levels for drinking water.

^bDuplicate.

^cU.S. EPA maximum contaminant level for drinking water.

-: Not detected.

NR - Not regulated.

Soil Gas Survey

Soil gases at JPL were sampled at the locations shown in Figure 5-6 using passive soil gas collectors consisting of a ferro-magnetic wire coated with activated charcoal contained in a glass culture tube. The culture tubes were buried open-end downward in 1-foot-deep holes drilled with a 3-inch-diameter hand auger, and the collectors were left undisturbed for approximately 4 weeks. A schematic diagram of a soil-gas collector buried in the ground is presented in Figure 5-7.

During the 4 weeks the collectors were left buried, any volatiles present in the soil beneath the collectors could adsorb onto the activated charcoal. The collectors were then removed, sealed immediately, and transported to the manufacturer's analytical laboratory (Petrex) where the adsorbed compounds were desorbed and analyzed using Curie-point mass spectrometry. The results were then compared to a library of mass spectra of known compounds and identified. Results are reported in terms of ion counts at various mass-to-charge ratios and provide a semi-quantitative measure of concentrations.

Results from the soil gas analyses were evaluated by using an order-of-magnitude ranking system in which net or background-corrected ion counts are ranked as not detected (zero ion counts), very low (1 to 4,999), low (5,000 to 9,999), moderate (10,000 to 49,999), or high (50,000 or greater). Duplicate wire collectors are averaged before ranking.

Six different volatile organic compounds (VOCs) were detected in one or more samples during the soil gas survey and are listed below.

- Benzene, toluene, and xylene (BTX)
- Trichloroethane (TCA)
- Trichlorofluoromethane (Freon 11) or Trichlorotrifluoroethane (Freon 13)
- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- Chloroform

Relative concentrations of these VOCs are presented in terms of net ion counts for each soil gas collector wire in Table 5-8, and major VOC detections are also shown in Figure 5-6. Equations relating ion counts with the true concentrations and flux of analytes in soil gas are not available.

The importance of the ESI work to the CERCLA effort was that it provided the first evaluation of on-site groundwater conditions, and it identified the presence of VOCs in certain monitoring

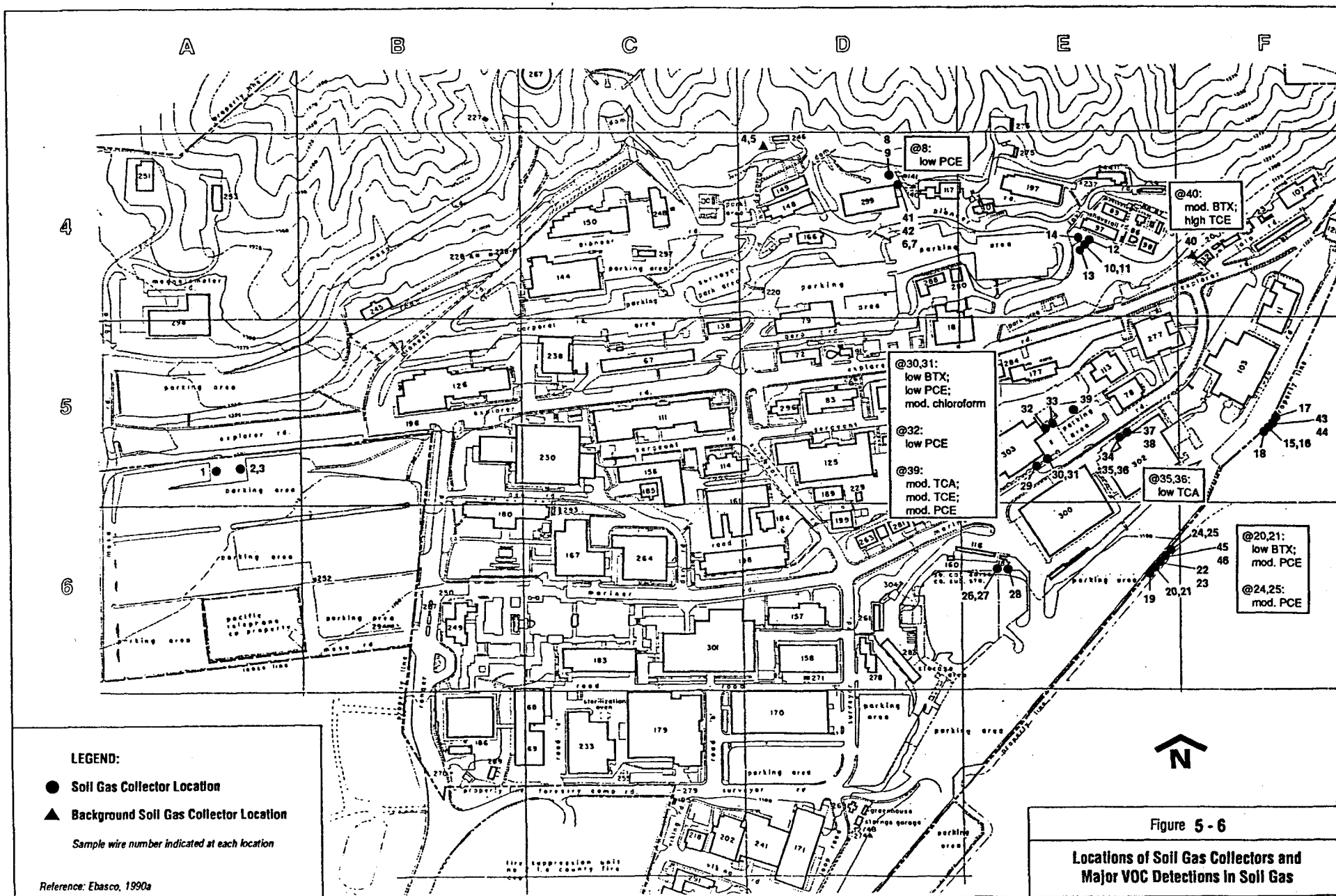


Figure 5-6

Locations of Soil Gas Collectors and
Major VOC Detections in Soil Gas

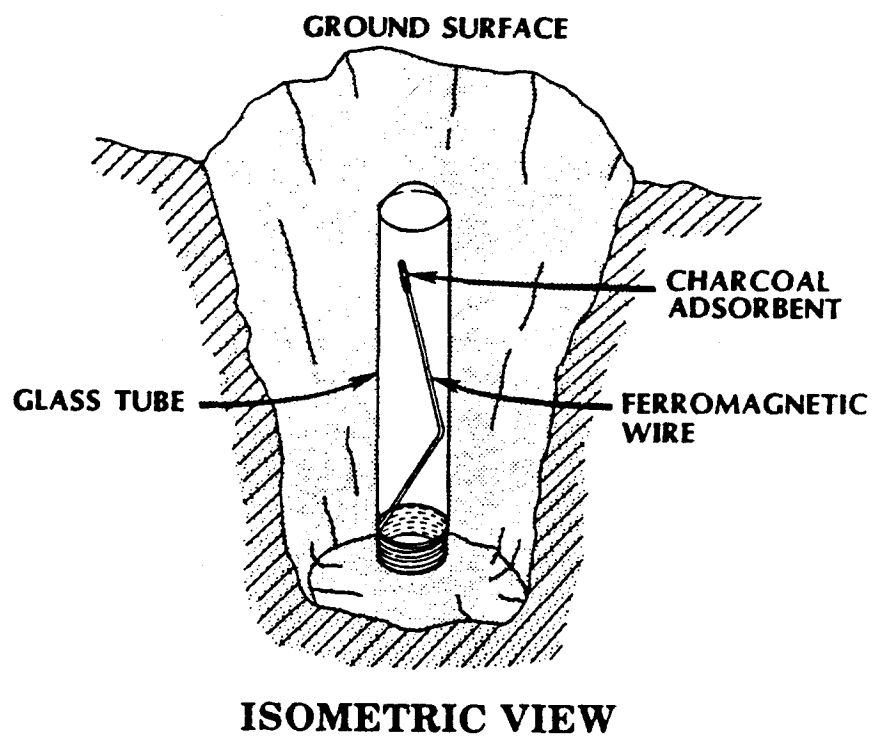


Figure 5-7

Schematic Diagram of Soil
Gas Collector

TABLE 5-8

**RELATIVE RANKING OF VOLATILE ORGANIC COMPOUNDS
DETECTED IN SOIL GAS SURVEY**

Wire Number	Collector Type	BTX	TCA	Freon 11 or 113	TCE	PCE	Chloroform
1	S	I	-	-	-	Negligible	-
2,3	D	V. Low	V. Low	V. Low	-	Negligible	-
4,5	D	I	-	-	-	Negligible	-
6,7	D	V. Low	V. Low	V. Low	-	Negligible	-
8	S	I	-	-	-	Low	-
9	S	V. Low	V. Low	V. Low	-	V. Low	-
41	S,T	NA	-	-	-	Negligible	-
42	S,T	NA	-	-	-	V. Low	-
10,11	D	V. Low	V. Low	-	-	V. Low	-
12	S	V. Low	V. Low	-	-	Negligible	-
13	S	V. Low	-	V. Low	-	Negligible	-
15,16	D	V. Low	V. Low	V. Low	-	V. Low	-
17	S	I	-	-	-	Negligible	-
18	S	I	V. Low	-	-	V. Low	-
43	S,T	NA	-	-	-	V. Low	-
44	S,T	NA	-	-	-	Moderate	-
19	S	V. Low	V. Low	V. Low	-	V. Low	-
20,21	D	Low	-	Moderate*	-	Moderate	-
22	S	V. Low	-	V. Low	-	V. Low	-
23	S	V. Low	-	V. Low	-	V. Low	-
24,25	D	V. Low	V. Low	V. Low	-	Moderate	-
45	S,T	NA	V. Low	-	-	Moderate	-
46	S,T	NA	V. Low	Low	V. Low	Moderate	-
26,27	D	V. Low	V. Low	-	-	Negligible	-
28	S	V. Low	V. Low	V. Low	V. Low	V. Low	-
30,31	D	Low	-	-	-	Low	Moderate
32	S	V. Low	-	V. Low	-	Low	-
33	S	V. Low	Low	V. Low	-	Moderate	-
34	S	V. Low	V. Low	V. Low	V. Low	Negligible	-
35,36	D	V. Low	Low	-	V. Low	Negligible	-
37	S	V. Low	V. Low	V. Low	V. Low	Negligible	V. Low
38	S	V. Low	V. Low	V. Low	-	Negligible	-
39	S	V. Low	Moderate	V. Low	Moderate	Moderate	-
40	S	Moderate	-	-	High	V. Low	-

NOTES:

Analyses are grouped according to location at the JPL site.

S - Single wire in one culture tube.

D - Double wires in one culture tube.

T - Time trial sample.

* - Probably not real.

I - Interference from organic materials emitted from conifers.

Negligible - for PCE only.

NA - Analyte not investigated.

- - Below detection limit.

wells that were the same as those found in the City of Pasadena wells. Information generated during the ESI provided significant input to the CERCLA effort and to the development of the work proposed in this work plan.

5.1.9 Ebasco Environmental (1990b)

After the ESI (Ebasco, 1990a) was completed, the Hazard Ranking System (HRS) scoring system methodology was revised by the EPA. The revisions increased the amount and detail of data required by the EPA to evaluate potential threats to public health and the environment while scoring a site for potential inclusion on the National Priorities List (NPL). A report (Ebasco, 1990b), that included additional information not previously provided to the EPA, was prepared and submitted so that the EPA could complete their HRS scoring for JPL with the newly revised system.

Discussions and data relating to waste characteristics, the groundwater migration pathway, the surface water migration pathway, the air migration pathway, and the on-site exposure pathway were included in this report (Ebasco, 1990b). Brief summaries of these discussions are presented below.

Waste Characteristics

After the completion of the ESI, additional information about past JPL waste-disposal activities and procedures were newly identified to further clarify the characteristics of wastes present at JPL. This information revealed that, of the original six waste pits identified previously in the PA and SI, only two of the pits were apparently constructed for the purpose of disposing wastes other than sanitary wastes. One of these pits (Pit 2, now designated as WP-2) was used mainly for glass and metal shaving disposal. The other pit (Pit 3, now designated as Seepage Pit No. 28) was suspected to have been used as a fluorine scrubber. This pit was originally designed to receive exhaust gases and neutralize any fluoric acid produced during experimental testing of a propulsion device that used fluorine gas as a propellant component. Two other pits (Pits 1 and 6) were apparently not actual "pits", but were open areas where various liquid wastes may have been disposed. Pit 1 could have been an erosional feature at the south end of Building 103, and this area is now designated as WP-1. Pit 6 is the location where Richard C. Slade obtained background soil samples for comparative purposes (see Section 5.1.4) during his investigations near former Buildings 59 and 65. The last two pits identified (Pits 4 and 5) were apparently cesspools (Seepage Pit Nos. 16 and 13, respectively) used for disposal of liquid and solid wastes. The cesspools were designed to allow liquid wastes to seep into the surrounding soil, and have apparently been referred to as seepage pits in the past. Information gathered during interviews with employees indicated that all the buildings present at JPL before the

current sewer systems were installed (circa 1960) had cesspools. The cesspools may have received various quantities of chemical wastes since most of the buildings at JPL either stored or used various chemicals. These cesspools are, or were, important potential sources of soil and groundwater contaminants at JPL.

Groundwater Migration Pathway

A map was prepared showing the locations of groundwater supply wells within a 4-mile radius for JPL and the population potentially served by each well. Copies of the well logs for the City of Pasadena supply wells and JPL monitoring wells were also included. In addition, groundwater sample analyses from a previous round of sampling and a new round of sampling were included.

The analytical results of water samples collected in November 1989 from four City of Pasadena water supply wells (the Arroyo Well, Well No. 52, the Ventura Well, and the Windsor Well) were also included and discussed. The water samples were analyzed for volatile organics (EPA Method 624), semi-volatile organics (EPA Method 625), major dissolved constituents, nitrates (NO_3), and selected metals including magnesium (Mg), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), aluminum (Al), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), selenium (Se) and silver (Ag). The volatile organic compounds detected in each well are shown in Figure 5-8. The results indicate the volatiles were present in three of the four wells sampled, but in concentrations generally below state and Federal drinking water standards. In the Arroyo Well, only CCl_4 and 1,2-dichloroethane (1,2-DCA) were present in concentrations above drinking water standards.

The analytical results of water samples collected in June 1990 from JPL monitoring wells MW-3 through MW-7 were also included and discussed. The water samples were analyzed for volatile organics using EPA Method 624, for Na, K, Ca, Mg, Fe, Cl, SO_4 , NO_3 , CO_3 , HCO_3 , F, PO_4 , total organic carbon (TOC), and total dissolved solids (TDS). Results of the volatile organic analyses are summarized in Table 5-9.

The upper two screened intervals of multi-port well MW-3 contained chloroform at levels below State of California, Department of Health Services (CDHS) drinking water standards. Toluene was detected in Wells MW-5, MW-6, and MW-7 at levels slightly above the analytical detection limit of $5 \mu\text{g/l}$. Xylene was also detected in Well MW-5 at a concentration of $11 \mu\text{g/l}$. Several volatile organics were detected in the sample from Well MW-7, including 1,1-DCE ($6 \mu\text{g/l}$), TCE ($27 \mu\text{g/l}$), PCE ($9 \mu\text{g/l}$), CCl_4 ($200 \mu\text{g/l}$), and chloroform ($19 \mu\text{g/l}$).

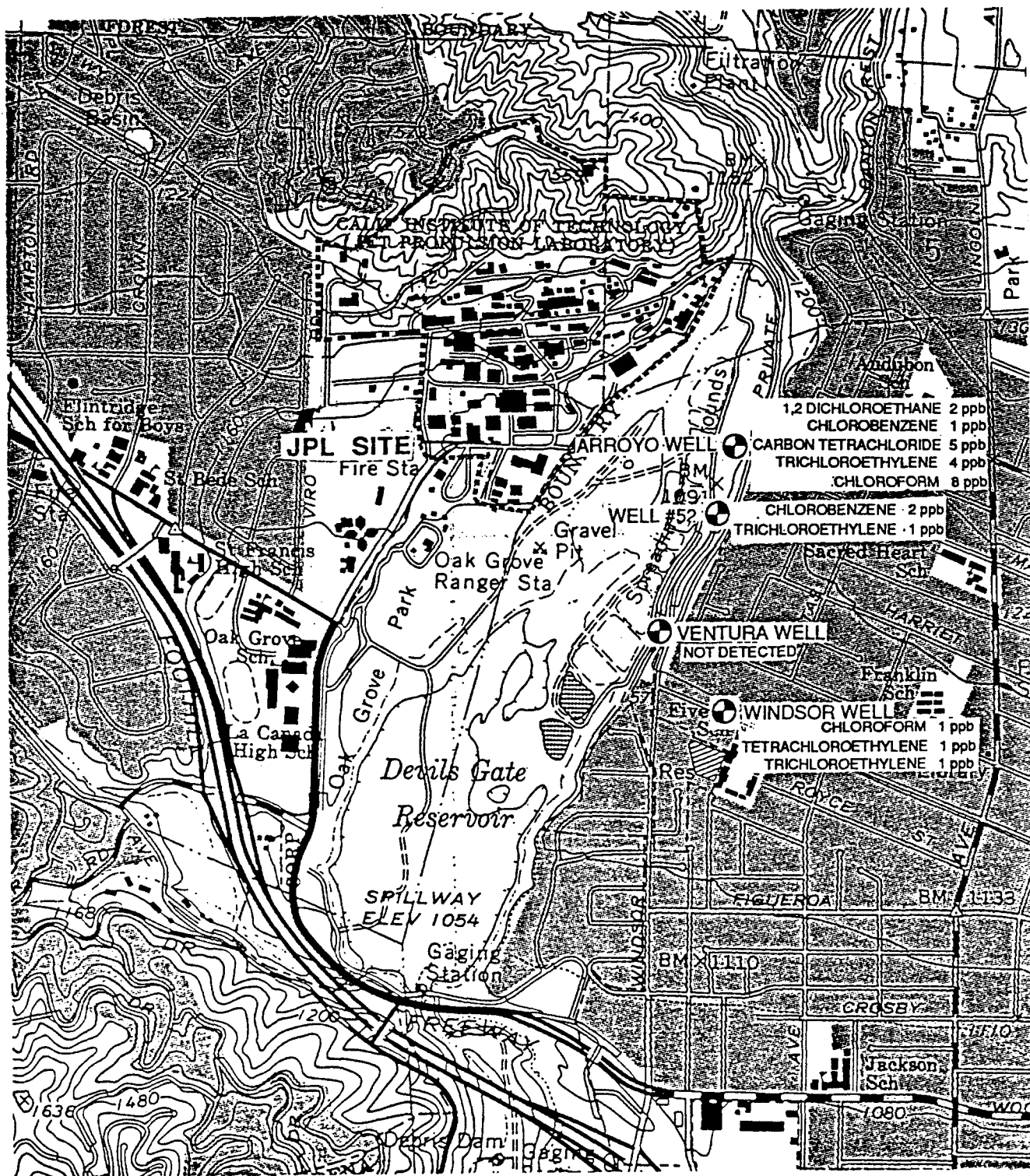


Figure 5-8

 PASADENA WELLS



**Detected Volatile Organic
Constituents in the Pasadena City
Production Wells, November 1989**

TABLE 5-9

**DETECTED VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES
COLLECTED DURING THE JUNE 1990 RESAMPLING OF JPL MONITORING WELLS**

(Concentrations reported in $\mu\text{g/l}$)

Well Number	Chloroform	Toluene	Total Xylenes	Carbon Tetrachloride	1,1-Dichloroethene (1,1-DCE)	Trichloroethene (TCE)	Tetrachloroethene (PCE)
MW-3 Screen 1	44	-	-	-	-	-	-
MW-3 Screen 2	6	-	-	-	-	-	-
MW-3 Screen 3	6	-	-	-	-	-	-
MW-3 Screen 4	6	-	-	-	-	-	-
MW-3 Screen 5	6	-	-	-	-	-	-
MW-4 Screen 1	6	-	-	-	-	-	-
MW-4 Screen 2	6	-	-	-	-	-	-
MW-4 Screen 3	6	-	-	-	-	-	-
MW-4 Screen 4	6	-	-	-	-	-	-
MW-4 Screen 5	-	-	-	-	-	-	-
MW-5	-	6	11	-	-	-	-
MW-6	-	6	-	-	-	-	-
MW-7	19	5	-	200*	6	27	9
Primary Standard**	100†	100††	1,750	.05	6	5	5

- Not detected.

* Dilution factor of 2.5.

** Maximum contaminant level established by the State of California Department of Health Services.

† Total trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform).

†† Drinking water action level recommended by the State of California Department of Health Services.

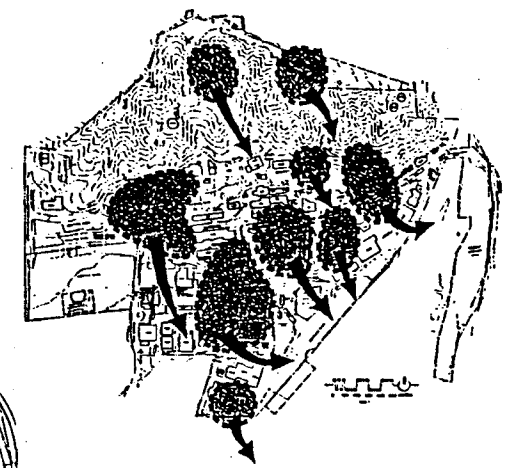
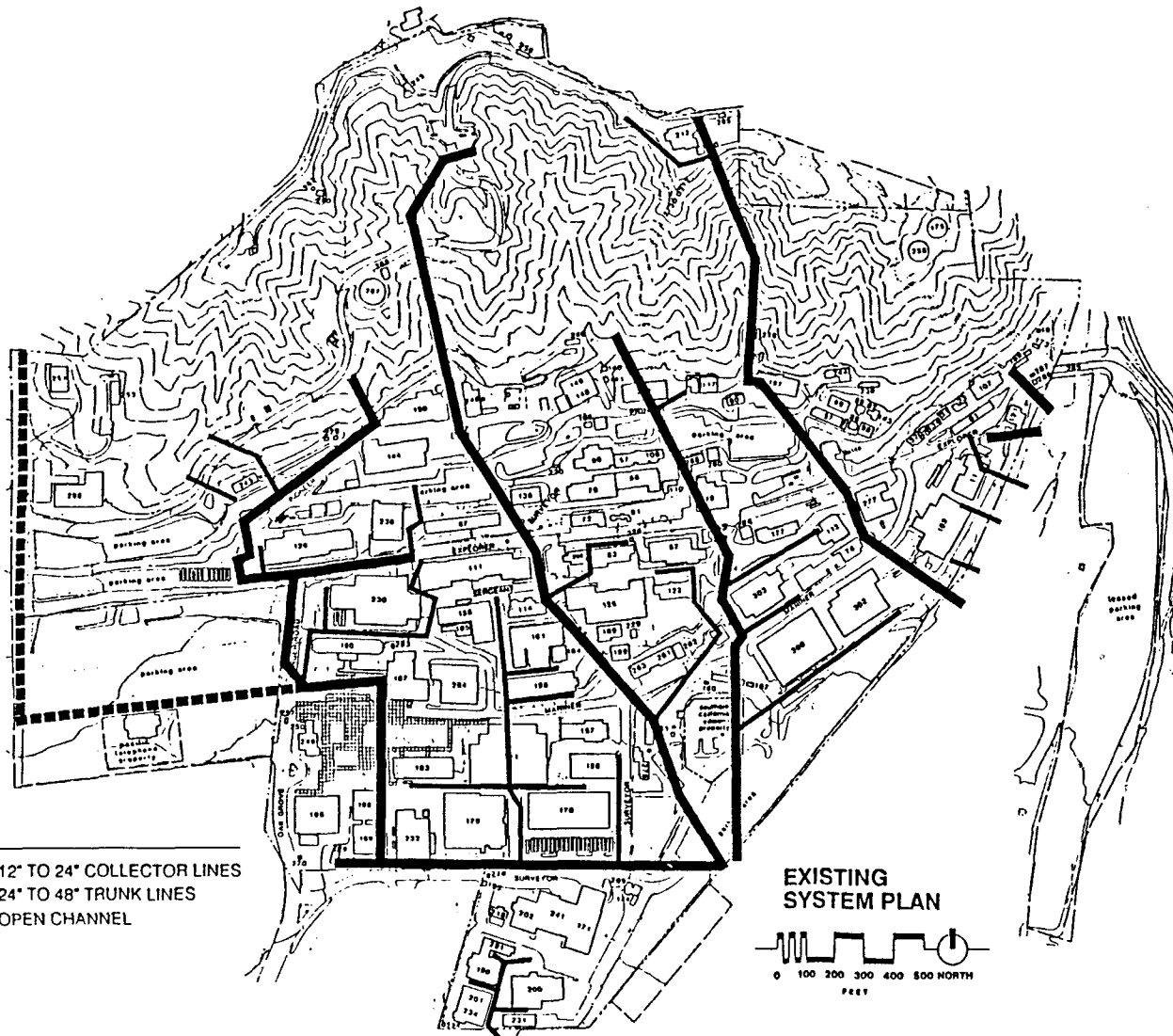
Surface Water Migration Pathway

Descriptions were provided on the physical characteristics of the ground surface at JPL, JPL's storm-drainage system, the physical characteristics and uses of the Arroyo Seco, stream-gauge data from the Arroyo Seco, watershed boundaries near JPL, potential targets 15 miles downstream of JPL, and the City of Pasadena's future plans for the arroyo.

JPL covers an area of approximately 176 acres. The northern half of the site is mountainous while the southern half of the site is moderately sloping and has been extensively graded. Elevations vary from 1,075 feet to 1,550 feet above mean sea level. Surface runoff on JPL is generally from north to south. Surface water from the mountains to the north is collected and transmitted by an underground storm-drain system through the developed southern portion of the site and is then discharged into the Arroyo Seco. The storm-drain system, designed to control runoff from a calculated maximum rainstorm within a 50-year period, includes four major drains (24 to 48 inches in diameter) that extend from the northern slopes and terminate at the arroyo. Branch lines (12 to 24 inches in diameter) collect local surface drainage and divert the water to the major drains (Boyle Engineering, 1988). A layout of the existing storm drain system is presented in Figure 5-9. Laboratory records and personnel documents indicate no problems with local flooding with the exception of unfinished construction sites. Existing piping is constructed of either vitrified clay (VC), reinforced concrete pipe (RCP), or corrugated metal pipe (CMP). At present, all materials except CMP is providing acceptable service. Pipe inverts constructed of CMP have undergone severe erosion. To correct the problem, a program to reline the CMP piping with cement to arrest the ongoing degradation of the lines has been initiated.

Surface sediment samples were collected from the stream channel in the Arroyo Seco at the locations shown in Figure 5-10. After 2 to 3 inches of sediment were removed from the surface, sediment samples were collected by driving a 2-inch by 6-inch stainless steel sample tube into the soil with a hand held, sliding hammer-drive soil sampler. The sediment samples were analyzed for volatile organics (EPA Method 8240), semi-volatile organics (EPA Method 8270), California Administrative Code Title 22 metals plus strontium (EPA Method 6010/7000), organochlorine pesticides and PCBs (EPA Method 8080), total petroleum hydrocarbons (TPH) (EPA Method 418.1), and cyanide (EPA Method 335.2). The analytical results of these analyses are summarized in Table 5-10. Locations of soil samples are shown in Figure 5-10.

No volatile organics, semi-volatile organics, organochlorine pesticides, or PCBs were detected in any near-surface sediment sample. Some metals, cyanide, and TPH were detected in low concentrations.



EXISTING
SYSTEM SCHEMATIC
LEGEND
--- TRIBUTARY AREA
→ FLOW COMPONENT



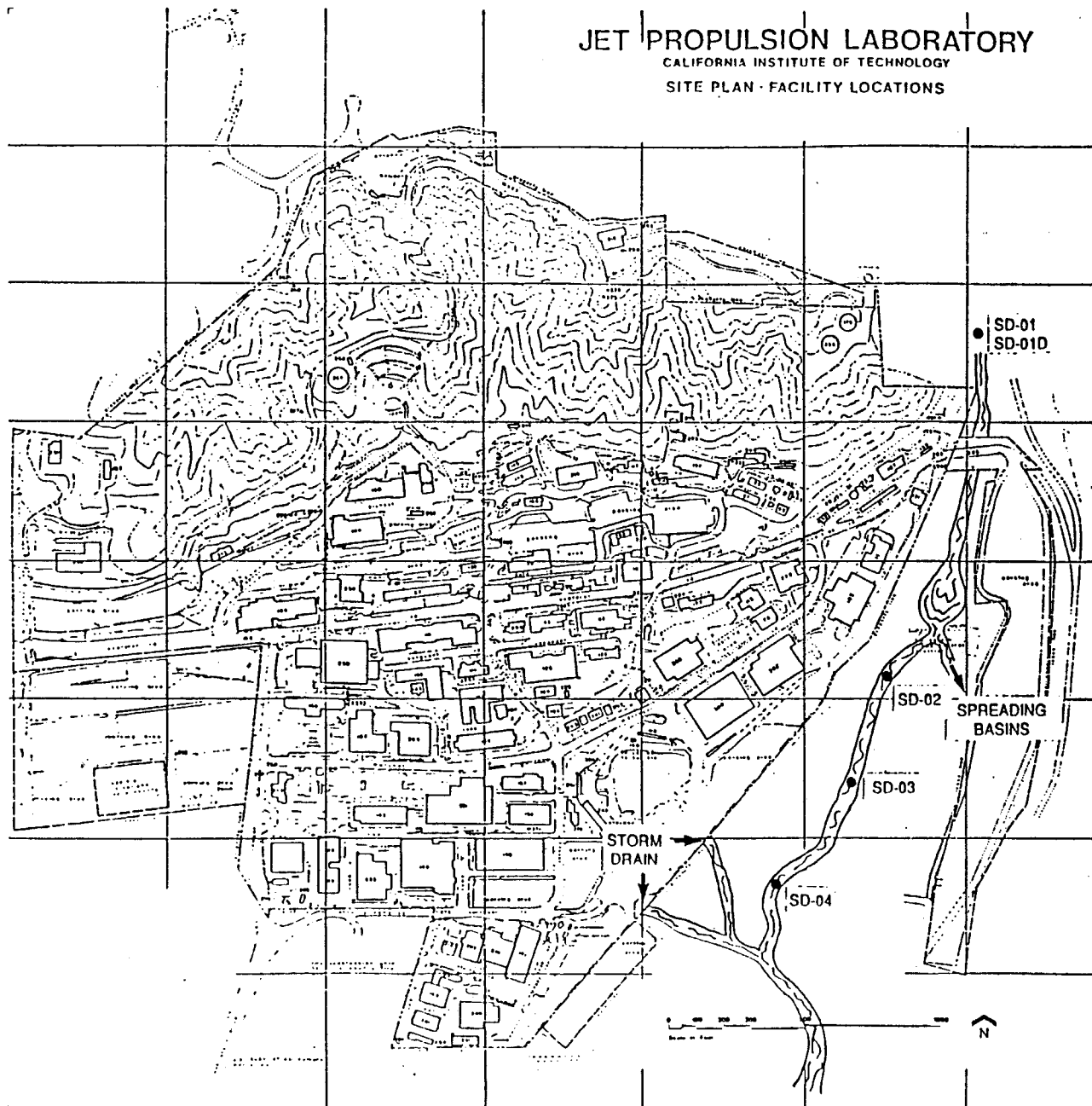
Source: Adapted from Boyle Engineering, 1988.

From: Supplemental Information to the Expanded Site
Inspection Report Dated November 1990

Figure 5 - 9

**Storm Drainage System at
Jet Propulsion Laboratory**

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
SITE PLAN - FACILITY LOCATIONS



LEGEND:

- SD-01 SEDIMENT SAMPLE LOCATION

Figure 5 - 10

Surface Sediment Sample Locations
Completed as Part of the HRS

Reference: Ebasco, 1990b

TABLE 5-10**CONSTITUENTS DETECTED IN SURFACE SEDIMENT
SAMPLES COLLECTED IN THE ARROYO SECO**

Sample Locations Shown in Figure 5-10

Constituent	Units	Sample Number					Regulatory Limits	
		SD-01	SD-01D	SD-02	SD-03	SD-04	TTLT (mg/kg)	STLC (mg/l)
Metals								
Barium	mg/kg	23	22	41	75	75	10,000	100
Beryllium	mg/kg	ND	ND	ND	ND	0.56	75	0.75
Cadmium	mg/kg	0.5	ND	0.76	1.2	1.2	100	1
Chromium (total)	mg/kg	2.8	2.8	4.6	8.0	8.4	2,500	560
Cobalt	mg/kg	2.6	2.5	3.9	7.2	7.3	8,000	80
Copper	mg/kg	5.3	5.3	13	18	16	2,500	25
Lead	mg/kg	16	5.5	15	36	26	1,000	5
Mercury	mg/kg	ND	ND	ND	0.13	0.12	20	0.2
Nickel	mg/kg	1.2	ND	3.4	4.5	4.3	2,000	20
Vanadium	mg/kg	6.3	5.6	9.6	18	19	2,400	24
Zinc	mg/kg	18	16	37	69	48	5,000	250
Strontium	mg/kg	20	21	21	61	56	NR	NR
Cyanide	mg/kg	ND	ND	ND	ND	0.4	NR	NR
Total Petroleum Hydrocarbons	mg/kg	ND	14	71	56	19	NR	NR

TTLT - Total Threshold Limit Concentrations, California Code of Regulations, Title 22.

STLC - Soluble Threshold Limit Concentration, California Code of Regulations, Title 22.

mg/kg - Milligrams per kilogram.

mg/l - Milligrams per liter.

ND - Not detected.

NR - Not regulated.

Sampling was conducted as part of the Hazard Ranking Score (Ebasco, 1990b).

Air Migration Pathway

Population counts were provided and land use was presented in concentric rings around JPL at intervals of zero to 0.25 mile, 0.25 to 0.5 mile, 0.5 to 1 mile, 1 to 2 miles, 2 to 3 miles, and 3 to 4 miles. Population counts within these concentric rings around JPL are tabulated in Table 5-11.

TABLE 5-11

POPULATION COUNTS WITHIN CONCENTRIC RINGS AROUND JPL

Radius (miles)	Population*	Cumulative Population
0 - 0.25	407	407
0.25 - 0.5	677	1,084
0.5 - 1	5,830	6,914
1 - 2	22,912	29,826
2 - 3	39,547	69,373
3 - 4	51,475	120,848

*Population estimates based on U.S. Census, 1980 Census Test Data (U.S. Department of Commerce, 1983).

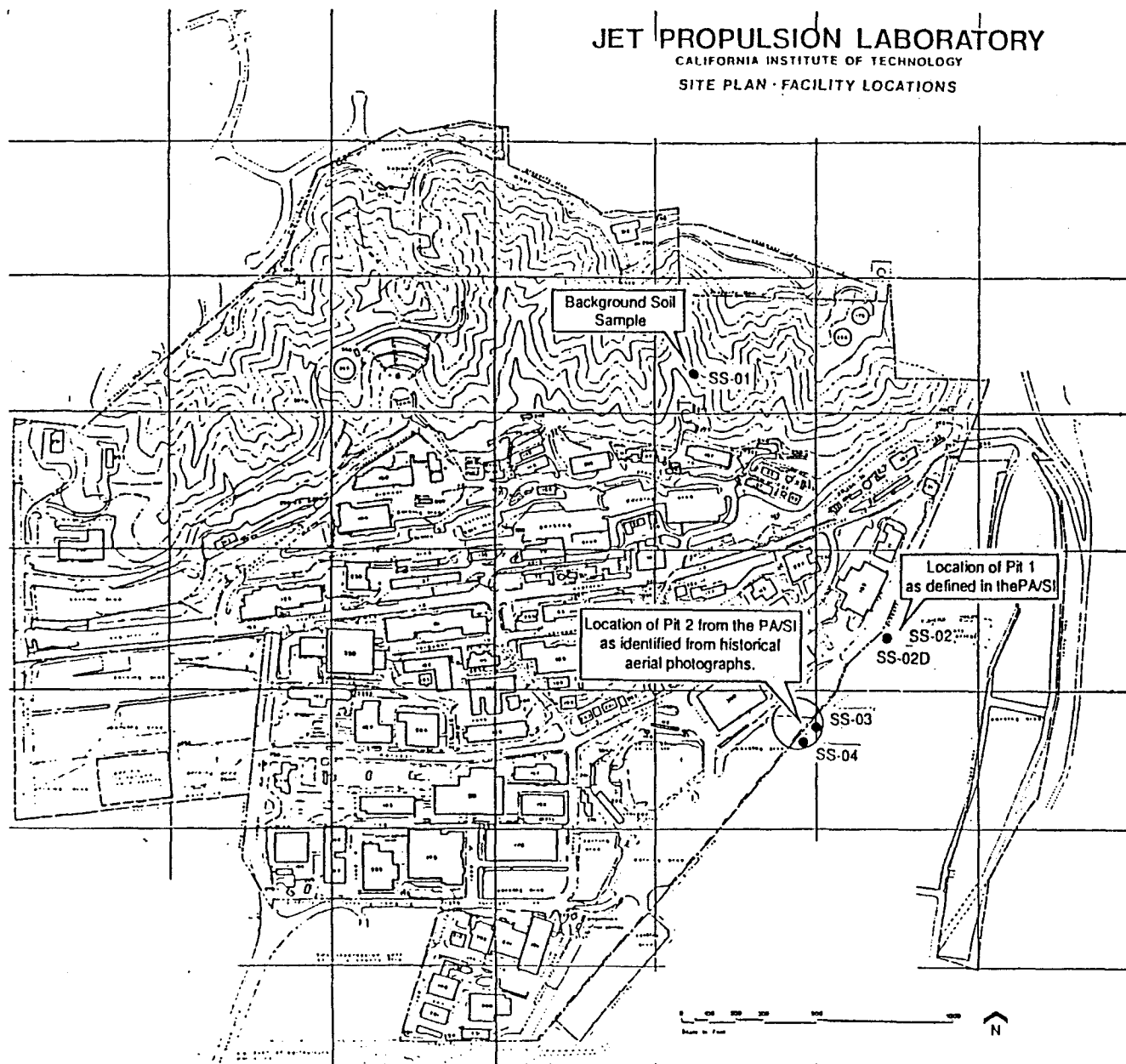
On-Site Exposure Pathway

Target populations of employees working at JPL and residents within 1 mile of JPL were presented along with a discussion on access restriction to the site. The resident population within 1 mile of JPL was estimated to be 6,914. In addition, employees numbered approximately 8,000 in 1990.

Since two of the former waste pits identified in the PA and SI (Pits 1 and 2) may have been located wholly or partially outside the current JPL property limits, soil borings were drilled and soil samples were collected to assess the possibility of human exposure to substances that may have been deposited in these pits. Four soil borings were hand augered to depths of 2 feet at the locations shown in Figure 5-11 and five soil samples (including a background sample and a QA/QC duplicate sample) were collected from a depth interval of 1.5 to 2 feet.

The soil samples were analyzed for volatile organics (EPA Method 8240), semi-volatile organics (EPA Method 8270), California Code of Regulations Title 22 metals plus strontium (EPA Methods 6010/7000), organochlorine pesticides and PCBs (EPA Method 8080), TPH (EPA Method 418.1), and cyanide (EPA Method 335.2).

JET PROPULSION LABORATORY CALIFORNIA INSTITUTE OF TECHNOLOGY SITE PLAN - FACILITY LOCATIONS



LEGEND:

● SD-01 SOIL SAMPLE LOCATION

Figure 5 - 11

**Soil Sample Locations
 Completed as Part of the HRS**

Reference: Ebasco, 1990b

No volatile organics, semi-volatile organics, organochlorine pesticides, PCBs, or cyanide were detected in any soil sample. Some metals and TPH, detected in low concentrations, are summarized in Table 5-12.

In summary, the supplemental information provided to the EPA was important to the CERCLA effort in that the information provided additional insight as to the nature of the potential contaminant-source areas, and it provided the basis from which an exhaustive contaminant research effort (Section 5.1.11) was initiated.

5.1.10 Jet Propulsion Laboratory (1990)

In November 1990, during a facilities project that involved the demolition of six buildings near the east gate (Buildings, 20, 23, 31, 32, 81, and 134) and realignment of Explorer Road, a construction crew demolished a large, in-service catch basin that was part of the site-wide storm-drain system installed more than 30 years ago. This portion of the site is historically the oldest area of activity at JPL and may have been an area subject to long-term chemical and solvent usage and subsequent disposal.

The catch basin was located about 20 to 25 feet in front of the east end of Building 107 and constructed of reinforced concrete. Plan dimensions were reported to be approximately 6 feet by 6 feet, and 10 feet deep. The top of the catch basin was level with the surrounding surface grade and contained an open steel grating that allowed storm-water runoff and associated debris to flow into the basin chamber. Additional runoff flowed into the chamber from an inlet pipe connected to two smaller catch basins located upstream. Solid materials entering the chamber were allowed to settle before water flowed out the discharge line that empties to the arroyo outside of the JPL property line.

At the time the catch basin was demolished on November 30, 1990, it contained approximately 4 feet of saturated, very dark gray silt and sand with about 2 feet of liquid on top. After the catch basin had been broken up, the basin's contents were reportedly going to be used as backfill material in the excavation and had been mixed with the surrounding soils. However, after mixing, the soils were recognized as being contaminated, and soil samples were sent to a laboratory for analysis on a "rush" basis. The samples were analyzed for total metals by EPA Method 6010/7000 series, cyanide by EPA Method 8010, total petroleum hydrocarbons (TPH) by EPA Method 8015 (modified for gasoline), pesticides and PCBs by EPA Method 8080, volatile organic compounds (VOCs) by EPA Method 8240, and semi-volatile organic compounds (SVOCs) by EPA Method 8270.

TABLE 5-12**CONSTITUENTS DETECTED IN SOIL SAMPLES COLLECTED ADJACENT TO JPL**

Constituent	Sample Number					Regulatory Limits	
	SS-01	SS-02	SS-02D	SS-03	SS-04	TTLT (mg/kg)	STLC (mg/l)
Metals							
Barium	170	78	110	31	30	10,000	100
Cadmium	1.2	ND	0.65	0.71	0.62	100	1.0
Chromium (total)	2.6	2.3	2.6	4.9	2.7	2,500	560
Cobalt	8.5	4.7	5.6	3.6	2.7	8,000	80
Copper	6.1	6.0	6.3	7.0	5.2	2,500	25
Lead	ND	4.9	8.0	11	ND	1,000	5.0
Nickel	1.8	1.8	1.9	2.2	1.1	2,000	20
Vanadium	15	7.5	11	6.8	5.9	2,400	24
Zinc	45	33	29	69	18	5,000	250
Strontium	21	14	19	13	20	NR	NR
Total petroleum hydrocarbons	ND	12	ND	29	ND	NR	NR

TTLT - Total Threshold Limit Concentration, California Code of Regulations, Title 22.

STLC - Soluble Threshold Limit Concentration, California Code of Regulations, Title 22.

mg/kg - Milligrams per kilogram.

mg/l - Milligrams per liter.

NR - Not detected.

NR - Sampling was conducted as part of the Hazard Ranking Score (Ebasco, 1990b).

Results of these analyses indicated that the soil materials in the catch basin contained carbon tetrachloride at an estimated concentration of 13,400 milligrams per kilogram (mg/kg) and lesser amounts of other solvents. A summary of detected VOCs and other chemical compounds identified by the analytical methods is presented in Table 5-13.

Approximately 60 cubic yards (cu yd) of material were excavated on December 15, 1990. In addition, when the excavation reached a depth of approximately 12 feet, part of an unmortared brick-lined seepage pit (see Seepage Pit No. 36, Table 5-17) was encountered. This pit was located directly beneath the concrete catch basin.

Three additional samples were taken from areas that visually appeared to be the most contaminated (darkest discoloration). Based on the analysis of these samples, another 100 cu yd of soil (including some concrete) were excavated on December 18, 1990. All excavated materials (total of 160 cu yd) were placed in roll-off bins and stored at the south end of the east parking lot until they were transported to the USPCI Class I landfill at Grassy Mountain, Utah. Available records do not indicate that additional soil samples were analyzed after the 160 cu yd of soil were removed from the site. The catch-basin excavation was backfilled with a mixture of lean-concrete.

The catch basin was uncovered as a part of routine facilities modification. While the work was not done as part of the CERCLA process, it did provide insight that the source identification efforts were properly focused.

5.1.11 Contaminant Source Research (1990 to Present)

Following the compilation of new information concerning contaminant-source identification and locations that was obtained during the revisions to the Hazard Ranking System score (Ebasco, 1990b), efforts were continued to search records, aerial photographs, drawings in the files, and to interview employees. These research efforts are still continuing and are expected to continue through the completion of the RI since new information is being discovered or developed.

Information from Interviews

In 1988, six disposal sites on JPL were identified as "seepage pits" and discussed in the PA and SI reports (Ebasco, 1988a and 1988b) and are shown in Figure 5-4 (see Section 5.1.6). After the Expanded Site Inspection (ESI) was completed (Ebasco, 1990a), additional information about past waste-disposal activities and procedures was found that assisted in clarifying the waste characteristics. The personnel interviewed are listed in Table 5-14.

TABLE 5-13

**SUMMARY OF DETECTED CHEMICAL COMPOUNDS IN SOIL SAMPLES
FROM STORM DRAIN CATCH BASIN**

Analysis	Concentration (mg/kg)	EPA Method
Volatile Organic Compounds:		8240
Acetone	335	
Methylene Chloride	834	
Carbon Disulfide	27	
1,1-Dichloroethane	51	
2-Butanone (MEK)	113	
cis-1,2-Dichlorethene	66	
Chloroform	720	
1,2-Dichloroethane	28	
Carbon Tetrachloride	13,400 (est)	
Trichloroethene (TCE)	55	
Toluene	27	
Tetrachloroethene (PCE)	23	
Chlorobenzene	28	
Total Xylenes	76	
Styrene	34	
Semi-Volatile Organic Compounds:		8270
1,4-Dichlorobenzene	9.9	
1,2-Dichlorobenzene	4.6	
Napthalene	5.1	
Di-n-Butylphtalate	9.2	
Metals:		
Arsenic	1.8	7061
Cadium	7.3	6010
Chromium (total)	124	6010
Copper	251	6010
Lead	125	6010
Mercury	34	7470
Nickel	724	6010
Zinc	636	8010
Cyanide	0.54	8010
Total Petroleum Hydrocarbons	4,640	8015M
Pesticides and PCBs	None	8080

Reference: Jet Propulsion Laboratory, 1990.

TABLE 5-14**PERSONNEL INTERVIEWED AT JPL**

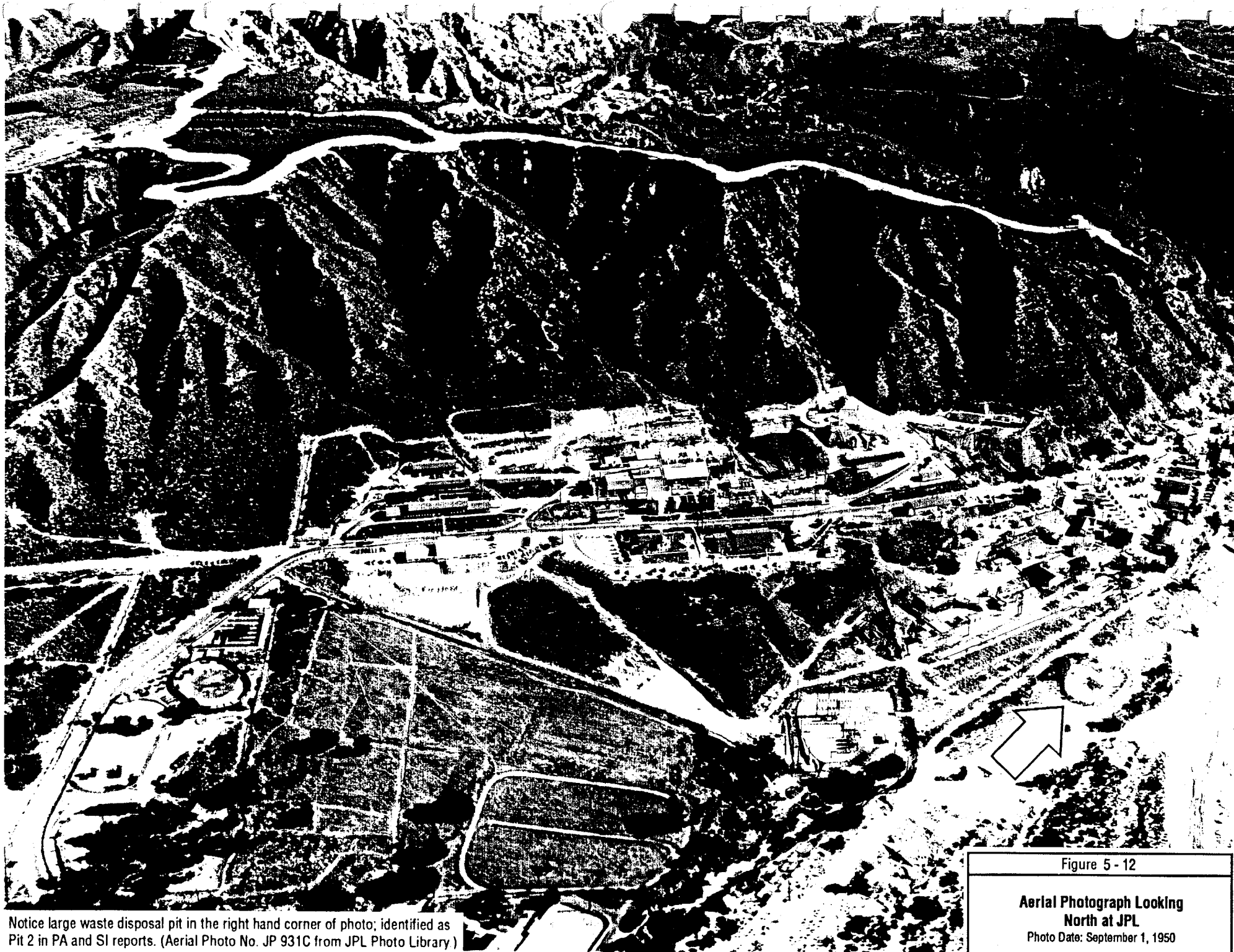
Name	Title or Affiliation
Roscoe Edwards (Retired)	Facilities Maintenance and Operation Section
Rich MacGillivray	Facilities Maintenance and Operation Section
Rudy Russ	Facilities Maintenance and Operation Section
Steve Stefanovich	Facilities Maintenance and Operation Section
Lane Prior (Retired)	Safety Officer
Don Boyer	Propulsion Section Administrator
Willis Thurston (Retired)	Test Pit Technician, Section Safety Coordinator
Bill Fehlings	Facilities Maintenance and Operation Section
Warren Dowler	Propulsion and Chemical Systems Section
Bill Beale	Observational Systems Section
Dick Mucciolo	Observational Systems Section
Ed Jones	Guidance and Control Section

It was learned that of the six waste pits previously identified in the PA and SI, only Pits 2 and 3 on Figure 5-4 were apparently constructed for the purpose of disposing wastes other than sanitary wastes. Pit 2 (now designated as WP-2) in this figure is shown on the aerial photograph in Figure 5-12. This unlined pit, bulldozed in the Arroyo Seco, was mainly used for the disposal of glass and metal shavings. Pit 2 can be seen in aerial photographs taken from 1947 to 1953, but is not present in an aerial photograph taken in 1959. Pit 3, on Figure 5-4, is shown on the aerial photograph in Figure 5-13. Pit 3 was identified as part of a test cell where a propulsion system that used fluorine gas was being developed.

To clarify the pit numbers used in previous documents and those used to identify the same features in this work plan, a comparative listing is presented in Table 5-15.

Pit 3 can be located on aerial photographs taken between 1940 and 1956, but it is not present on an aerial photograph taken in 1958. Both former Pit 2 and Pit 3 can be seen on the aerial photograph in Figure 5-14.

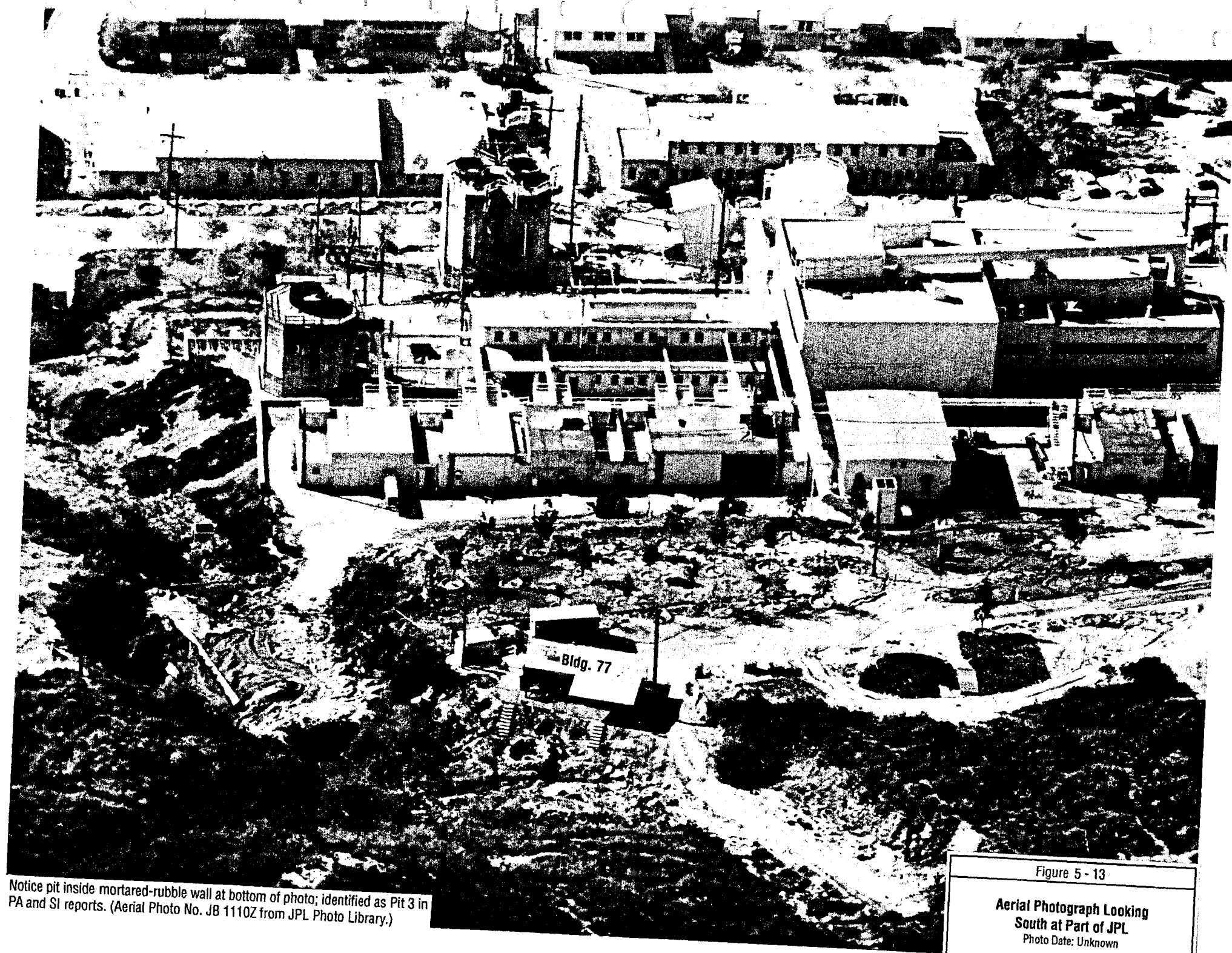
Pit 1 and Pit 6, as identified in the PA and SI, were not actually "pits" as such, but were open areas where wastes may have been conveniently disposed. Pit 1 (now designated as WP-1) was described as a pit, but it could have been a channel or gully caused by erosion at the location where a 36-inch-diameter storm drain empties into the Arroyo Seco near the south end of



Notice large waste disposal pit in the right hand corner of photo; identified as Pit 2 in PA and SI reports. (Aerial Photo No. JP 931C from JPL Photo Library)

Figure 5 - 12

**Aerial Photograph Looking
North at JPL**
Photo Date: September 1, 1950



Notice pit inside mortared-rubble wall at bottom of photo; identified as Pit 3 in PA and SI reports. (Aerial Photo No. JB 1110Z from JPL Photo Library.)

Figure 5 - 13

Aerial Photograph Looking
South at Part of JPL
Photo Date: Unknown



Notice Pit 2 from in the Arroyo and Pit 3 from the PA and SI reports along lower ledge of JPL. (Aerial Photo No. JP 931H from JPL Photo Library.)

Figure 5 - 14

**Aerial Photograph Looking
South at JPL**

Photo Date: September 1, 1950



Notice Pit 2 from in the Arroyo and Pit 3 from the PA and SI reports along lower ledge of JPL. (Aerial Photo No. JP 931H from JPL Photo Library.)

Figure 5 - 14

**Aerial Photograph Looking
South at JPL**

Photo Date: September 1, 1950

Building 103. Spent mercury was reportedly dumped in this area at one time. Pit 6 actually was the location where Richard C. Slade (Slade, 1984) obtained background soil samples from an exploration trench during his investigations at former Buildings 59 and 65.

It was also learned during the interviews that, in the 1940s and 1950s, many buildings at JPL used a cesspool to dispose of sanitary liquid and solid wastes. These cesspools, seepage pits in current terminology, were designed to allow liquid wastes to seep into the surrounding soil. Pits 4 and 5, as identified in the PA and SI, were seepage pits that served former Buildings 59 and 65, respectively. Other information indicated that many of the seepage pits at JPL may have received various quantities of chemical wastes since most of the buildings at JPL either stored or used various chemicals. This new insight on potential contamination sources prompted a diligent search of historical construction drawings for buildings with plumbing connections to seepage pits.

Based on drawings in the microfiche files located in the Facilities Engineering offices, 27 seepage pits were identified by the time the supplemental report (Ebasco, 1990b) for the ESI was completed. A summary of those seepage pits and the buildings to which they were connected are listed in Table 5-16. Most of the older buildings, where seepage pits were used, were located in the northeast section of JPL.

It was later learned that a former salvage storage area located just southeast of existing Building 248 was reportedly used for the disposal of solvents. The area was mistakenly reported, during an interview, as being located near existing Building 144. However, the alleged disposal area is located about 300 feet east of Building 144 and is shown as WP-3 in Figure 6-1 (Section 6.1.2). Approximately three 55-gallon drums of solvents at varying concentrations were dumped into three hand-dug holes every 3 to 4 months over a period of 2 to 3 years during the late 1950s. The holes were approximately 25 feet apart, about 4 feet wide by 3 feet deep, and were located east of former Building 119 that was identified in the aerial photograph included as Figure 5-15.

It was reported that, most likely, the solvents disposed were from cleaning parts and would have been a mixture of trichloroethene, acetone, M50 (trichloroethane), alcohol, and toluene. It was believed that carbon tetrachloride was not in use at JPL during the period of time that the salvage yard was in this area. These disposal holes may be very critical in the evaluation of contaminant sources since they are located upgradient from monitoring well MW-7. Groundwater samples from MW-7 have contained several volatile organic compounds.

TABLE 5-16**SEEPAGE PIT NUMBERS AND ASSOCIATED BUILDINGS**

Seepage Pit No.	Building Number	Building Name
1,2	3	Superintendent of Mechanics' Office
1,2	4	Mechanics' Assembly Shop
3,4	11	Electrical and Plumbing Shops and Stores
9	13	Offices, Lab and Shop
1,2	17	Lunch Counter
1,2	19	Restrooms
1,2	22	Thermocouple Lab
15	34	Shop-test Cell #33 (Liquid Propellants)
9	44	Credit Union
14	46	Shop-test Cell #42 (Liquid Propellants)
18,19	52	Test Cell "X" Observation Building
17	55	Solid Propellant Mixing Lab
16	59	Paint Shop
20,21	63	Ramjet Shop
8,13	65	Materials Lab
23,24,25	67	Engineering Building and Labs
5	68	Electric and Plumbing Shop
5	71	Mechanics Stores
12	74	Chemistry Test Cell
26	77	Experimental Chemistry Lab
10	78	Hydraulics Lab
18,19	90	Shop-test Cell #51 (Solid Propellants)
11	101	Transportation Offices and Shop
7	103	Fabrication Shop and Inspection
11	104	First Aid and Fire Department
27	246	Soils Test Lab
6	*	*
22	*	*

*Currently unknown.

Source: Facilities Engineering microfiche and drawing files at JPL.

Reference: Supplemental Information to the ESI Report (Ebasco, 1990b).



Salvage Yard and Building 119 is in upper right of photo. Dumping reportedly occurred in vicinity of the 'X'. (Aerial Photo No. JB 1673B from JPL Photo Library.)

Figure 5 - 15

**Aerial Photograph Looking
West at JPL**

Photo Date: February 27, 1958

The three areas of concern where waste disposal reportedly occurred (Pits 1 and 2 and southeast of Building 248) are represented by the shaded areas in Figure 6-1 (Section 6.1.2) and are designated WP-1, WP-2, and WP-3, respectively.

Seepage Pit Location Procedures

JPL's Facilities Engineering office maintains all plans, construction drawings, and building records for almost every structure that has been constructed on the laboratory's grounds. Some plans and plan files for certain buildings are missing from the early days. A microfiche file in the Facilities Engineering offices contains negatives for thousands of drawings that have been placed in archive storage. These microfiche can be reviewed rapidly for required information and printed by the microfiche-viewing machine at about one-half scale of the original drawing. It is from this microfiche file, and hard-copy prints from the negatives, that most of the information on the locations, construction details, and uses of the seepage pits has been derived.

Subsequent to preparation of the ESI (Ebasco, 1990a) and prior to completing the Supplemental Information to the ESI report (Ebasco, 1990b), 27 seepage pit or dry well locations were located based on hard copy drawings and on drawings in the microfiche files at JPL. Thirteen additional seepage pits were identified in the interim period between the supplemental report and completion of the draft RI work plan (Ebasco, 1991).

The procedures used in locating and identifying the seepage pits included the following:

- Review microfiche files for buildings constructed prior to installation of the sewer system (early 1960s).
- Make paper print from microfilm negative for each drawing that may provide information in determining locations of seepage pits.
- Calculate scales of drawings printed from microfiche file.
- Calculate approximate coordinates of seepage pit if drawing (plot plan, grading plan, plumbing plan, building details, etc.) is tied to JPL's coordinate system.
- Transfer location of seepage pit by plotting its approximate coordinates on master map.
- If coordinates are not indicated, enlarge or reduce copy of print for use as an underlay to transfer estimated seepage-pit location to master map by matching preserved reference points.
- When dimensions were shown on printed drawing, the scaled dimensions were used to plot the seepage-pit location on the master map.
- Numbers assigned to the seepage pits are in the order that the pits were discovered, and they were randomly applied when more than one pit appeared on the same drawing.

Seepage Pit Descriptions

Information on the seepage pit descriptions (e.g., construction details, piping, drawing numbers, etc.) has not appeared in any of the documents prepared prior to this work plan. The seepage pit designations shown in the text and on the figures are current designations and will be used throughout the remainder of the project.

Seepage Pit Nos. 1 and 2

These two seepage pits were connected in tandem and were used to dispose of liquid wastes from former Buildings 3, 4, 17, and 22 and sanitary wastes from Building 19. Locations of these five buildings, the seepage pits, and drain lines are shown on a pre-1949 drawing prepared by the U.S. Army titled "Master Plumbing Plan for East Portion." This plan was designated as Drawing No. JPL0901A-0. Names for these buildings are not shown on the drawing, and records regarding their use are very limited.

Construction drawings for Buildings 3, 4, 17, 19, and 22 are not known to exist. However, it is speculated that the seepage pits were not used for sanitary-waste disposal since the drain lines from each of these buildings consisted of 2-inch-diameter cast iron pipe that extended long distances before joining with a 4-inch-diameter vitrified clay pipe. A 4-inch-diameter cast iron pipe extends from Building 19 to the vitrified clay pipe indicating that restrooms were probably inside this building. Details on the construction of the pits are not available.

Since these pits are located in the area having the oldest use-history on the JPL, it is possible that chemicals or solvents may have been disposed in them.

Seepage Pit Nos. 3 and 4

Seepage Pit Nos. 3 and 4 were constructed in tandem along the north side of existing Building 11 at the locations shown on JPL Drawing No. JPL0901A-0 and used to dispose sanitary wastes from restrooms and a small "kitchen area" (JPL Drawing No. 11/1-0). Drain lines from these rooms consist of 4-inch-diameter cast iron pipe that extend a few feet outside of the building before joining with a 4-inch-diameter vitrified clay pipe leading to the seepage pits.

Building 11 was originally designed to house the administrative and engineering offices for the facility and was maintained for these functions a number of years. The building was modified extensively in 1951, and it is indicated on JPL Drawing No. 11/81-0 that Seepage Pit Nos. 3 and 4 may have been abandoned at that time. Restrooms were moved to the south side of the building and supposedly connected by cast iron and vitrified clay pipes to other existing seepage pits. Locations of these other seepage pits are neither dimensioned nor shown to scale in

relation to the building on any available drawing. Hence, their exact locations have not been determined. However, details on JPL Drawing No. 11/81-0 indicate that the pits were constructed with unmortared brick and had a minimum depth of 15 feet.

Prior to 1960, Building 11 was converted to house electrical and plumbing shops and related storage areas for supplies. Solvents are routinely used in repairing, cleaning, and maintaining electrical and plumbing equipment, hardware, tools, and machinery, and spent solvents could have been discharged to the seepage pits prior to being connected to the sewer system.

Seepage Pit No. 5

The location of Seepage Pit No. 5 was on the south side of former Building 127 and received sanitary wastes from this building and similar wastes from former Buildings 68 and 71 according to plumbing details on JPL Drawing Nos. 71/1-0 and JPL0901A-0. Seepage Pit No. 5 received wastes from Buildings 71 and 127 via a 4-inch-diameter vitrified clay pipe. A 4-inch cast iron pipe tied into that line from Building 127. A 6-inch-diameter vitrified clay pipe was used to convey wastes from Building 68 to the seepage pit. Construction details on the seepage pit are not available; however, it is believed that the pit's location is in the lawn area east of existing Building 277.

Building 68's function and use is unknown since there are no records for this building in the JPL files. Building 71 was originally used for shipping and receiving at the facility and was later converted to "mechanics stores." Building 127 is believed to have been used for vehicle maintenance since details on JPL Drawing No. 71/1-0 indicate long manway pits for lubricating the underside of vehicles and the location of an Autolite sparkplug cleaner. Solvents and petroleum hydrocarbons used in Building 127 could have been dumped into drains and sinks.

All three buildings are located in close proximity to old solid-propellant bunkers and may have been used intermittently to store chemicals and solvents used in the mixing and development of propellants.

Seepage Pit No. 6

The location for this seepage pit is shown on Drawing No. JPL0901A-0 only, and no piping is shown to indicate which building it may have served. However, since Seepage Pit No. 6 was located in an area where surrounding seepage pits (Nos. 5, 7, 7A, 7B, 8, 9, and 10) were suspected to be potential sources of chemical or solvent contaminants, it could also be a potential contaminant source.

Seepage Pit Nos. 7, 7A, and 7B

Seepage Pit No. 7 was installed about 15 feet south of the original Building 103, a machine shop in which oils, solvents, and chemical degreasers were used. Additions to the building were built over Seepage Pit No. 7 and necessitated the construction of two additional seepage pits (7A and 7B) farther south. The locations of pits 7A and 7B are shown on JPL Drawing 103/7-0. All three seepage pits were designed to collect sanitary wastes from restrooms.

Building 103 housed a machine shop, metal fabrication shop, and a metal pickling room. Solvents were and still used routinely for cleaning and degreasing. It was reported that liquids were dumped into a "drain hole" near the southeast corner of the building. This "drain hole" may well have been one of the clean-out pipes for either Seepage Pit No. 7A or 7B.

Construction details on both of the referenced drawings indicate that the seepage pits were constructed of unmortared brick 5 feet in diameter and were to have minimum depths of 20 feet below finished surface grade. Four-inch-diameter cast iron pipe was used to carry wastes outside of the building's footprint before joining a 6-inch-diameter vitrified clay pipe that discharged into Pit No. 7. Both 4-inch-diameter cast iron and vitrified clay pipe were used to tie Pit No. 7 with Pit Nos. 7A and 7B.

Seepage Pit Nos. 8 (Dry Well), 13, and 13A

Seepage Pit Nos. 8, 13 and 18A were all connected to the interior plumbing of former Building 65. Former Building 65 was used as a materials laboratory that housed two chemistry labs and a chemical-storage area, X-ray and metallurgy lab with a dark room, microscope room, a physics laboratory equipped with a universal testing machine, offices, and a library. Seepage Pit Nos. 8 (dry well), 13, and 13A served former Building 65 in three different ways. Seepage Pit No. 8 was actually a 3-foot-square by 3-foot-deep concrete dry well to collect liquids originating from a pit in the floor where a universal testing machine was located, Seepage Pit No. 13 collected liquid waste from the north side of the building where chemistry laboratory rooms with counter-top and floor sinks were located, and Seepage Pit 13A collected sanitary wastes from the restrooms located on the south side of the building. Locations of the two seepage pits and dry well with respect to Building 65 are shown on JPL Drawing Nos. 65/2-3 and 65/44-0. A fourth seepage pit on the east side of the building was indicated on Drawing JPL0901A-0 but could not be found on the actual construction drawings.

Seepage Pit No. 13 was investigated by Richard C. Slade (Slade, 1984) using a backhoe to obtain soil samples for analysis (see Section 5.1.4) following the buildings' demolition. The

only significant finding in Slade's study of this seepage pit was an elevated level of lead with a concentration of 200 mg/kg in an undisturbed soil sample from a depth of 7 feet.

Based on the information presented on the construction drawings, 2-inch-diameter cast iron pipe connected the testing-machine pit to the dry well and was also used to drain the chem-lab sinks to Seepage Pit No. 13.

A combination of 4-inch-diameter cast iron and vitrified clay pipe was used to carry sanitary wastes from the restrooms to Seepage Pit No. 13A. The cast iron pipe extends only 3 feet outside of the building's footprint before connecting with the vitrified clay pipe.

The locations of the two seepage pits and dry well now lie within the footprint of Building 302, the Microdevices Laboratory, which is a two-story structure with a deep basement. To construct the foundations and bottom floor for Building 302, 18 to 21 feet of soil had to be excavated from the building's west side. Since the building site sloped to the east, only about 6 to 8 feet of material were required to be removed from that side of the construction area. There is no documentation in available files on the removal of seepage pits during the excavation operations.

Seepage Pit No. 9

The origin and purpose for Seepage Pit No. 9 is not well documented. It is not known if the pit was originally connected to former Building 44 (the old credit union building), or earlier portions of former Building 13 that housed offices and a small workshop. It is indicated on JPL Drawing No. 13/14-1 that Building 13 was constructed over the seepage pit with the notation "approximate location existing cesspool to be filled after service is discontinued" shown on the drawing. On Drawing No. JPL0901A-0, a cesspool and connection piping is shown to be connected to Building 44, but the seepage pit is located southwest of Building 13. No other records on this seepage pit could be found in available records. However, in either case, the seepage pit locations are well within the footprint of existing Building 302.

Seepage Pit No. 10

Seepage Pit No. 10 was located approximately 15 feet from the northeast corner of Building 78 and is believed to be covered presently by a concrete retaining wall and a bank of horizontally stacked nitrogen gas tanks. The pit's approximate location is shown on JPL Drawing Nos. 78/2-0 and 78/37-0. Drain lines from a lavatory sink and a water closet were connected to the seepage pit via a section of 4-inch-diameter cast iron pipe and an extension of 6-inch-diameter vitrified clay pipe. Lengths of these sections are not shown on the drawings. Construction details for the seepage pit are not available.

Building 78 was first designed and used for housing large hydraulic testing machines. This building is referred to as the Hydraulics Laboratory even though the testing machinery was removed a number of years ago. A number of smaller laboratories were housed in this building during its history and included a small laser laboratory, a ceramics room, the "Ocean's Lab," and a cryogenic sensor technology laboratory. Today, one half of the building is occupied by the Space Cryogenics Laboratory and the other half by JPL's glassblowing shop.

Since solvents are often used to clean up machinery and degrease parts, the likelihood of solvents being used in the hydraulics laboratory is high, and these solvents may have been disposed by pouring them into the lavatory sink.

Seepage Pit No. 11

This seepage pit was used to collect sanitary wastes from former Buildings 101 (Transportation Offices) and 104 (First Aid Building) and was located approximately 40 feet downslope to the southeast as indicated on Drawing JPL0901A-0. Both of these buildings housed restrooms, but interior piping information is not available. Exterior piping, as shown on the referenced drawing, consisted of 4-inch-diameter vitrified clay.

Based on the historical use of these buildings, it is unlikely that interior drains were used to dispose liquid chemicals or solvents.

Seepage Pit No. 12

This seepage pit was located approximately 15 feet northwest of former Chemical Test Cell Building (Building 74) adjacent to existing Building 78's southwest side. Construction details for the seepage pit are shown on JPL Drawing No. 74/23-0.

Building 74 was constructed for testing chemical and liquid propellants, and solvents were used for cleaning and degreasing equipment and hardware. Although only a small sink in this building was connected to the seepage pit via 5 feet of 2-inch-diameter cast iron pipe and 10 feet of 4-inch-diameter vitrified clay pipe, the clean-out for the seepage pit was located just outside of a later-constructed entrance to Building 78 and accessible for dumping chemicals or solvents directly into the pit. It was reported that spent chemicals were poured into the sink on several occasions. Seepage Pit No. 12 was constructed of unmortared brick and had an inside diameter of 4 feet.

Seepage Pit Nos. 13 and 13A

(See Seepage Pit No. 8)

Seepage Pit No. 14

Seepage Pit No. 14 was located approximately 20 feet northwest of former Building 46, a workshop building that supported an adjacent liquid propellant test cell (Test Cell "G") housed in Building 42. The location of this seepage pit is shown on JPL Drawing Nos. 42/2-0 and JPL0901A-0.

Solvents were reportedly used to clean the propellant testing devices, hardware, and exhaust areas following the actual tests. The solvents were commonly stored in the shop building. Small spills occurred frequently, and it is possible that spent solvents and other chemicals may have been poured into the shop's counter-top sink.

Sanitary wastes from the restroom were carried through a 4-inch-diameter cast iron pipe to a point at least 3 feet outside the building where this pipe connected to a 6-inch-diameter vitrified clay pipe that drained to the seepage pit. A 2-inch-diameter cast iron pipe connected the sink drain to the 4-inch cast iron pipe outside the building.

Construction details for the seepage pit are not available, but it is assumed that it was of similar construction (unmortared brick) to others located in the area.

The site of former Building 46 now lies within the footprint of existing Building 302, and the seepage pit is believed to be near the sidewalk under the elevated porch leading to the building's main entrance.

Seepage Pit No. 15

According to JPL Drawing No. 33/2-2, Seepage Pit No. 15 was located approximately 38 feet northwest of former shop Building 34 that was demolished prior to constructing Building 300. The old seepage pit location is believed to be adjacent to or under the foundations for Building 300.

This seepage pit collected liquid wastes from a small counter-top sink in Building 34, which served as a work shop area associated with former test-cell Building 33 (Test Cell "F") where various types of liquid propellants were test fired. Solvents and other cleaning agents used in the liquid propellant test cell to clean equipment and hardware may have been stored in

Building 34. Small chemical spills reportedly occurred in the test cell over a period of several years, and may also have been disposed by pouring into the sink.

Materials used in constructing the seepage pit are not shown on the drawings, but it is believed that unmortared bricks were used since these materials were found at other nearby seepage pit locations (Seepage Pit Nos. 13 and 16). Dimensions of Seepage Pit No. 15 are also not available. The drain line connecting the sink to the seepage pit was constructed with 4-inch-diameter vitrified clay pipe.

Seepage Pit No. 16

Located approximately 17 to 18 feet southwest of former Building 59, this seepage pit was constructed to receive liquid wastes from a sink inside the building, which originally housed a paint shop and spray booth. Building 59 was later converted to a chemistry laboratory.

During the term that the building served as a paint shop, the potential for disposing paint solvents and thinners into the sink was high. In later years, the sink remained in easy access for the disposal of chemicals.

Seepage Pit No. 16 was investigated by Richard C. Slade using a backhoe for excavating exploration trenches to locate the seepage pit and obtain soil samples for chemical analyses (see Section 3.6.1.4). Slade located the pit, which was constructed of unmortared brick, and obtained undisturbed and bulk samples within the upper 8 feet of soil. Results of the chemical analyses conducted revealed no significant findings.

Construction details of the piping (shown on JPL Drawing 59/1-0) indicate that 2-inch- and 4-inch-diameter cast iron pipe were used to connect the sink to the seepage pit. Also, based on the available information, the seepage pit location is near the northern end of the elevated patio railing along the east side of present Building 303. Building 59 would have been located partly in the area occupied by Building 303's patio and partly in the parking lot on the building's north side.

Seepage Pit No. 17

As shown on Drawing No. JPL0910A-0, this seepage pit was located 60 to 65 feet from former Building 55, which was a solid propellant mixing facility. Construction drawings of the building's interior are not available, but it is assumed that the building housed facilities similar to those in other buildings where solid propellants were prepared. Hence, sinks and tubs for soaking and cleaning the mixing equipment were probably present in Building 55.

Solvents (e.g., carbon tetrachloride, methyl ethyl ketone, trichloroethene, and cyclohexanone) were routinely used to clean the mixing hardware and reportedly disposed, on occasion, by pouring into the sinks and tubs before connections to the sewer system were completed.

A 6-inch-diameter vitrified clay pipe connected the building's drain pipes to the seepage pit. Based on the size of the clay piping, Building 55 probably housed restroom facilities in addition to cleaning sinks.

The area previously occupied by Building 55 is presently a parking area for NASA trucks and buses located near Building 280.

Seepage Pit Nos. 18 and 19

These two seepage pits are connected in tandem to currently existing Building 90 with 4-inch-diameter cast iron pipe and are situated west and southwest of the building (JPL Drawing Nos. 77/25-0 and 90/9-0). Building 90 served as an observation and shop facility for a former solid propellant test cell (Building 51 that was referred to as Test Cell "X") and housed restroom facilities and sinks.

It was reported that test motors and other hardware were cleaned by soaking in tubs of solvents (including acetone and carbon tetrachloride) that were not recycled and allegedly dumped into sumps (Seepage Pit Nos. 18 and 19) on the west side of Building 90 or at the east end of the solid propellant preparation area.

Details on the seepage pits are not available, but they are assumed to be constructed with unmortared bricks since these materials were used in seepage pits at other buildings constructed during the same time frame.

Seepage Pit Nos. 20 and 21

Former Buildings 58 and 63 were joined together and, in combination, housed large compressors, maintenance shops for the compressors and other machinery. By 1960, the combined structure was referred to as Compressor Building 58. Seepage Pit No. 20 was connected to the original Building 63 by approximately 40 feet of 4-inch-diameter cast iron pipe with a 60-foot extension of 6-inch-diameter vitrified clay pipe. The locations of Seepage Pit 20 and the pipeline are shown on Drawing JPL0902A-1. Following the merger of designations for Buildings 58 and 63, a second seepage pit (Seepage Pit No. 21) was constructed about 16 feet east-southeast of Pit No. 20 (JPL Drawing No. 77/25-0). Information on the type and size of the pipe connecting the two seepage pits is unavailable.

Neither construction drawings nor interior plans for Building 63 are in the available files, so the interior draining system (including restrooms, sinks, floor drains) is not known.

Solvents are routinely used to clean parts and machinery, and are commonly stored where they are used. Spent solvents could have easily been poured into sinks or floor drains (if present).

Former Building 58 has been demolished and the two seepage pit locations are covered by a filled and graded parking lot. In addition, the location of Seepage Pit No. 21 may underlie the foundation for the retaining wall on the south edge of the parking lot adjacent to the north side of Aero Road.

Seepage Pit No. 22

The location of Seepage Pit No. 22, as shown on JPL Drawing No. 77/25-0, is near former Building 80 that housed a wind tunnel. Construction details for the seepage pit, piping, and Building 80 are not in JPL's files.

Based on information available, there were no reports of solvents or chemicals being used in this building.

The area formerly occupied by Building 80 is presently an asphalt-paved parking lot north of existing Building 79, and the parking lot is covered by office trailers. The seepage pit location is beneath the office trailers.

Seepage Pit Nos. 23, 24, and 25

Locations of these three seepage pits are shown on Drawing No. JPL0902A-0. They served existing Building 67 by collecting liquid and sanitary wastes from a diverse number of small laboratories and four restrooms. Although primarily an office building, small laboratories and research rooms (e.g., biology, kinetics, low-level radioactive, magnetics, computer development, range correction, spectroscopy, etc.), as well as storage rooms for finished components and parts, were housed in Building 67 during its history of occupancy. Several of these laboratory rooms existed prior to connecting with the sewer system.

There are no records for the types and amounts of chemicals used in this building and their usage was unknown to interviewees. Also, construction details for the seepage pits are not available. As indicated on Drawing JPL0902A-0, 6-inch-diameter vitrified clay pipe was used to convey the liquid and sanitary wastes to the seepage pits from the interior 4-inch-diameter cast iron plumbing lines. Seepage Pit Nos. 23 and 24 are beneath the asphalt-paved parking area

along Explorer Road south of the building's central section, and Seepage Pit No. 25 is beneath a walkway or landscaping near the west end of the building on its south side.

Seepage Pit Nos. 26 and 28

Seepage Pit No. 28 has been referred to as a "dilution tank" (JPL Drawing No. 77/1-0), an "acid sump" (JPL Drawing No. 77/2-0), a "fluorine pit" (JPL Drawing No. 77/4-1), and a "cesspool" (JPL Drawing No. 77/21-1). In actuality, the pit was originally designed and constructed to receive exhaust gases from a fluorine propellant test cell located in former Building 77. A 23-foot-long steel pipe having an inside diameter of 18 inches sloped downward from the test cell, at an angle of 30 degrees, to the pit that was situated on the building's north side. Notations on JPL Drawing No. 77/2-0 called for the pit shaft to be constructed 4-foot square with "walls to be of suitable material" to a depth of 15 feet, plus or minus, with a 2-foot-thickness of crushed limestone at the bottom. It is indicated on JPL Drawing No. 77/1-0 that the shaft was 5 feet in diameter and 20 feet deep. Floor drains located in two of the building's rooms were connected to the shaft by 2-inch- and 4-inch-diameter cast iron pipes.

Building 77 also housed an experimental chemistry laboratory and various chemicals may have been dumped into the exhaust shaft (Seepage Pit No. 28). Crushed limestone was placed at the bottom of the shaft to neutralize fluoric acid produced during experimentations with fluorine propellants. Interviewees reported that numerous chemicals were disposed by dumping into available "sumps" near the building.

Seepage Pit No. 26 was located on the south side of Building 77 and received both liquid and sanitary wastes from, respectively, sinks and a restroom. Exterior piping consisted of 4-inch-diameter vitrified clay (JPL Drawing No. 77/33-0). Construction details for this seepage pit and the building's interior plumbing are not available.

Most of the area formerly occupied by Building 77, including Seepage Pit No. 28, is now covered by existing Building 299. However, the location of Seepage Pit No. 26 is believed to be in Pioneer Road near the west end of Building 299 (JPL Drawing No. 299C010A0-0). It should be noted that both of these seepage pits are located upgradient from monitoring well MW-7.

Seepage Pit No. 27 (Dry Well)

Seepage Pit No. 27 is a dry well constructed of precast reinforced concrete pipe sections topped with a standard concentric cone section of similar materials. The pit receives liquid wastewater through a 2-inch-diameter cast iron pipe from two small counter-top sinks located in Soils

Laboratory Building 246. These construction details, as well as the dry well's location, are shown on JPL Drawing No. 246/3-10.

Primary activities at Building 246 involved experimentation with soil conditioning and various types of vegetation to evaluate the most effective methods for revegetating slopes and controlling erosion. There is no history or knowledge of solvents or petroleum products having been used at this location.

Seepage Pit No. 29

According to JPL Drawing No. 32/1-0, Seepage Pit No. 29 was located between former Buildings 32 and 20 in the liquid propellant testing area. Building 32 housed the test cell where solid propellants were fired during the late 1940s and liquid propellants during the mid-1950s. Building 20 was the shop used to provide support for the test cell in Building 32.

The seepage pit was designed for collecting liquids from two floor drains located in the test cell. Each drain was located near the center of sloped gutters along opposing walls in the test cell's firing bay. The drains were connected to the seepage pit by 4-inch-diameter vitrified clay pipe. It is noted on the referenced construction drawing that the seepage pit was to have a 4-foot inside diameter and extend to a depth of 16 feet with no overflow. Construction materials were not specified. Unmortared bricks were probably used to construct the pit's shell since some red bricks were excavated from that location when Buildings 20 and 32 were demolished and the area regraded for constructing a parking lot.

Solvents were commonly used to clean the propellant testing motors and associated hardware. It has been reported that solvents, degreasers, and chemical cleaners were applied with rags, paint brushes, or spray bottles and then wiped-down by hand or hosed-off with water. Solvents commonly used during JPL's early years included carbon tetrachloride, methyl ethyl ketone, and acetone.

Seepage Pit No. 30

Existing Building 117 formerly housed a solid propellant test cell and a seepage pit was located approximately 7 to 8 feet from the south wall near the southwest corner of the building (JPL Drawing Nos. 117/50-0 and 117/50-4). A small counter-top sink was located inside the building opposite the seepage pit location. Restrooms were not housed in the building. Construction details are not available for either the seepage pit or the piping connections.

Solvents were commonly used to clean rocket motors and hardware, and these solvents reportedly were not recycled, but were disposed of by dumping into nearby sumps and drains.

Seepage Pit No. 31

As shown in location and grading plan details on JPL Drawing No. 107/69-0, Seepage Pit No. 31 is located about 9 feet due south of Building 112's (now Building 107) southwest corner almost directly between Building 112 and former Building 12. Piping diagrams are not shown on this drawing and there is a possibility that the seepage pit was connected to both buildings. Restroom facilities were not located in Building 112 and records for Building 12 are not available.

At one time, Building 112 housed two liquid propellant test cells. In the early 1960s, this building merged with Building 107 (also a test cell for liquid propellants), and the combined structure is presently referred to as Building 107. This combined structure later housed plasma flow and laser research laboratories, and it is currently associated with laser and robotics development.

Solvents were used routinely in the liquid propellant test cells for cleaning and degreasing experimental firing equipment and hardware. Spills commonly occurred, but were reportedly small.

The purpose for Seepage Pit No. 31 is not clear, and construction details (other than location) regarding it's size, depth, and composition are not available.

Seepage Pit No. 32

This seepage pit is located on the south side of existing Building 86 and apparently collected liquid wastes from existing Buildings 98, 87, and, possibly, 88. The pit's location is shown on JPL Drawing No. 98/1-0, which includes piping details on drains coming from Building 98 (containing 5 floor drains), and lead-in drains originating at Buildings 86 and 87. Exterior piping is indicated as both 4-inch-diameter vitrified clay and cast iron, while interior piping consists of 2-inch-, 3-inch-, and 4-inch-diameter cast iron.

A plumbing diagram on JPL Drawing No. 88/1-0 shows a 4-inch-diameter vitrified clay pipe leading away from the building. The drawing detail notes "4 (in.) VC to dry well, see plot plan." However, the plot plan could not be found in JPL's records. This line could run to Seepage Pit No. 32, or it could lead to another unidentified pit west of Building 86. In fact, the plumbing diagram on JPL Drawing No. 86/7-3 does not show a seepage pit at the location

indicated on Drawing 98/1-0, but does show an exterior 3-inch-diameter cast iron pipe leading westward from the inferred seepage pit location at Building 86 with the notation "3 (in.) CI soil pipe to cesspool, see plot plan."

Buildings 86, 87, 88, and 98 are all located at the east end of the solid propellant preparation area where numerous types of solvents were used to clean mixing equipment and hardware.

No other construction details on Seepage Pit 32 are available.

Seepage Pit No. 33

According to the plumbing details shown on JPL Drawing No. 97/1-0, Seepage Pit No. 33 is located 16 feet from the west end of existing Building 97 and collected liquid wastes from 4 counter-top sinks, two floor drains, and a series of unidentified wall-mounted inlets. Two- and 4-inch-diameter cast iron pipe was used inside the building and connected to an exterior 4-inch-diameter vitrified clay pipe leading to the seepage pit.

Restroom facilities, located on the north side of Building 97 near its east end, are shown on Drawing No. 97/1-0 to be connected to an unidentified pipe exiting the building, but no indication is given as to its destination. No other information is available on piping, connections, or construction of the seepage pit.

Building 97 was a development laboratory for solid propellant chemistry experimentation and numerous solvents were used to clean laboratory hardware, including acetone, carbon tetrachloride, methyl ethyl ketone, and trichloroethene. During the employee interviews, it was reported that sumps in the vicinity of Building 97 were used to dispose spent solvents.

Seepage Pit No. 34

On JPL Drawing No. 98/2-1, Seepage Pit No. 34 is noted as a 20-foot-deep dry well located about 9 feet north of the east end of existing Building 98. A floor drain in a small exterior storage area was connected to the dry well by 4-inch-diameter cast iron pipe. This building was originally designated as "Cleaning and Spray Building" and housed a larger "cleaner room" with a floor that sloped to a drain in the center of the floor. A 4-inch-diameter interior cast iron pipe and 4-inch-diameter vitrified clay pipe connected this drain to Seepage Pit No. 32 located on the south side of Building 86 as shown on JPL Drawing Nos. 98/1-0 and 98/7-0. A roofed solvent-storage area underlain by a concrete slab is shown on the drawing to be adjacent to the dry well.

Building 98 was later (early to mid 1950s) converted to a solid propellant preparation shop. Solvents were used to clean mixtures of propellant chemicals and binders from mixing equipment and related hardware. Reportedly, a pit at the east end of the solid propellant preparation area in the vicinity of Building 98 was used for disposal of carbon tetrachloride, methyl ethyl ketone, trichloroethene, cyclohexanone (maybe), and other chemicals after the sewer system was installed.

Seepage Pit No. 35

This seepage pit received liquid and sanitary wastes from former Building 81 that housed offices, workshops, storage rooms, and restrooms. The seepage pit was located approximately 35 feet in a southeasterly direction from the building's western end according to plot-plan details on JPL Drawing Nos. 81/3-2 and 81/43-0. Sanitary wastes were conveyed from the east end of the building through a 4-inch-diameter vitrified clay pipe that joined with a 6-inch-diameter vitrified clay pipe from the building's west end just before connecting with the seepage pit.

Construction details for the seepage pit are not available, but it is assumed that it would be similar to others nearby that are constructed with unmortared brick. Also, it is indicated on the referenced drawings that this seepage pit was also connected to Seepage Pit Nos. 1 and 2.

Seepage Pit No. 36

This seepage pit was discovered during the removal of a large, storm drain catch basin that was constructed directly over the top of the pit. It's location is not shown on any plans or drawings in available files, so it cannot be determined which building was connected to Seepage Pit No. 36. However, because it was located approximately 20 to 25 feet in front of Building 107, it may have been connected to this building at one time. Construction workers reported that the pit was 4 to 5 feet in diameter and constructed with unmortared red bricks.

Soil sludge in the demolished catch basin was reported to contain elevated concentrations of carbon tetrachloride, acetone, trichloroethene, methyl ethyl ketone, tetrachloroethene, styrene, and mercury. Detailed information is presented in Section 5.1.10.

Seepage Pit No. 37 (Dry Well)

As noted on Drawing No. JPL0901A-0, this seepage pit was described as a dry well and was connected to Building 2 that housed an inspection and gage laboratory. The purpose for the dry well, as well as details on it's construction piping, and size are not available.

The final number of seepage pits identified during this effort was 40 since Seepage Pit Nos. 7A, 7B, and 13A are included in the total count.

5.1.12 Ebasco Environmental (1991)

In January 1991, a pre-RI draft work plan for additional contaminant-source exploration and groundwater characterization was prepared based on all information available at that time. The planned scope of work included the drilling and sampling of soil borings at suspected contaminant-source locations and the installation of monitoring wells to further evaluate the lateral and vertical extents of on-site and off-site volatile organic compounds (VOCs). Following the completion of the field work, all of the analytical data collected, with the incorporation of existing data, would be evaluated as part of a risk assessment (RA) to potential receptors. The purpose of that effort would be to quantify risks posed by the VOCs in groundwater and source areas and set forth criteria that could be used to evaluate remedial alternatives.

It was planned that at least 22 borings would be drilled and sampled to a depth of 100 feet at accessible seepage pit locations and at other locations where there was high probability that solvents and chemicals had been allowed to seep into the subsurface soils or dumped. Based on the chemical analysis of samples from these borings, other secondary seepage pit locations in close proximity to those explored would also be drilled and sampled. In addition, if it could be determined that other seepage pit locations were accessible to drilling equipment, they would also be drilled and sampled.

Two seepage pits (Nos. 22 and 27) were eliminated from the pre-RI exploration program because there was either no evidence of solvent or chemical usage associated with their history, and 11 other seepage pit locations (Nos. 4, 7, 8, 9, 10, 11, 13, 13A, 25, 28, and 32) are inaccessible to drilling equipment because of terrain or by being located under existing structures. A listing of the 40 seepage pits and dry wells identified at the time the draft work plan was prepared is presented in Table 5-17 and their locations are shown in Figure 5-16.

Installation of four monitoring wells was also planned. Three of these wells would be shallow standpipe wells having a screened interval of 50 feet at the bottom of each well. The fourth well, a multiple-screened well having at least five 10-foot sections of screen at various depths within the aquifer, would be on the order of 650 to 700 feet in total depth. The purposes for these wells are to obtain water-quality samples downgradient from suspected contaminant sources and to help assess the vertical extent of volatile organic compounds in the groundwater.

In summary, this work plan was submitted to EPA prior to listing on the NPL. It was believed much of the work would be valuable regardless of when the work was completed. As a result,

TABLE 5-17

SEEPAGE PIT DESIGNATIONS AND INFERRED USE

Seepage Pit No.	Associated Building No.	Building Still Exists (Yes/No)	Current Area Use	Inferred Use
1 & 2	3, 4, 17, 19, 22	No No	Parking lot north of Building 11.	Pits connected in tandem and located in area having oldest use-history on JPL site; recent discovery of solvents and other contaminants in nearby seepage pit that was uncovered during construction work in 1990.
3 & 4	11	Yes	Planter west and north of Building 11, respectively.	Pits connected in tandem; Building 11 housed plumbing and electrical shops where solvents may have been used.
5	68, 71, 127	No	Lawn east of Building 277.	Original uses of Buildings 68 and 127 are not known; Building 71 was used as "mechanics stores." Buildings are located near old solid propellant bunkers and may have been used to store solvents used in mixing and developing propellants.
6	Unknown		Mariner Road.	Implications are similar to those for Seepage Pit Nos. 1, 2, 3, 4, and 5.
7, 7A & 7B	103	Yes	Under Building 103. Under electrical substation on south side of Building 103.	Building housed machine shop, fabrication shop, and metal pickling room; solvents used for cleaning and degreasing; alleged dumping of liquids in "drain hole" near southeast corner of building.
8 (DW)	65	No	Under Building 302.	Dry well plumbed to collect liquids originating from pit in building's floor where universal testing machine was located.
9	13 or 44	No	Under Building 302.	True location of pit is questionable; may have been connected to Building 13, which housed a small workshop, or the old Credit Union Building 44.
10	78	Yes	Under retaining wall foundation and bank of nitrogen gas tanks.	Building 78 housed a hydraulics laboratory; solvents commonly used to clean machinery and degrease parts.
11	101, 104	No	At base of slope near retaining wall north of Building 113.	Collected sanitary wastes from transportation offices (Building 101) and First Aid Building 104. Potential for disposal of solvent or hydrocarbon wastes from Building 101.

TABLE 5-17

(Continued)

Seepage Pit No.	Associated Building No.	Building Still Exists (Yes/No)	Current Area Use	Inferred Use
12	74	No	Planter area south of Building 78.	Chemistry test cell (liquid propellants); solvents reportedly used for cleaning and degreasing; disposal of chemicals reported to have occurred by pouring into drains.
13 & 13A	65	No	Under Building 302.	Materials laboratory; may have housed machinery and metals cleaned with solvents; also housed chemistry laboratory; bottom of pit in building for universal testing machine drained to dry well.
14	46	No	Under entryway to Building 302.	Shop for liquid propellant test cell; implications are same as those for Seepage Pit Nos. 12 and 15.
15	34	No	Adjacent to or under foundations of Building 300.	Shop building associated with old test cell buildings (Test Cell "F") and liquid testing facility; spilled solvents reportedly small, but did occur on regular basis over several years.
16	59	No	North end of elevated patio on east side of Building 303.	Building housed old paint shop; high potential for paint solvents having been disposed in seepage pit serving facility.
17	55	No	Parking lot near Building 280.	Solid propellant mixing facility; solvents used to clean mixing hardware were disposed by pouring into sumps prior to installation of sanitary sewer system.
18 & 19	90	Yes	Under Pioneer Road.	Shop for test cell No. 51 (solid propellant testing in Test Cell "X"); test motors and hardware soaked in tubs of solvents (included carbon tetrachloride and acetone) that were not recycled and allegedly dumped into sumps on west side of Building 90 or at east end of solid propellant preparation area (east of Building 88).
20 & 21	63	No	Under or behind retaining wall foundations.	Compressors and maintenance shop; solvents routinely used for parts cleaning. Soils beneath both seepage pits could be sampled with single angle boring.
22	80	No	Under office trailers.	Wind tunnel building; no history of solvent or chemical usage.

TABLE 5-17

(Continued)

Seepage Pit No.	Associated Building No.	Building Still Exists (Yes/No)	Current Area Use	Inferred Use
23 & 24, 25	67	Yes	Parking area along Explorer Road. Beneath walkway at top of slope.	Building's history is diverse. Although mainly an office building, several small laboratories (biology, kinetics, low-level radioactive, and spectroscopy) were located within the structure over a several-year period--possibly before connections made to sanitary sewer system.
26 & 28	77	No	Under Building 299. In planter or under Pioneer Road.	Structure housed experimental chemistry lab and fluorine propellant test cell with an acid-neutralizing pit constructed similar to a dry well; numerous chemicals reportedly disposed by dumping into available sumps near building. Seepage pit is upgradient from monitoring well MW-7.
27 (DW)	246	Yes	Asphalt paved parking area.	Dry well from sink at former soils test laboratory; no history of solvent or chemical usage.
29	32	No	Asphalt paved parking lot.	Test cell used for liquid propellant testing since mid-1950s; solid propellants used during late 1940s. Seepage pit located near area where ongoing construction work disclosed solvent contamination in storm-drain catch basin and previously unknown seepage pit.
30	117	Yes	Asphalt paved parking area.	Building housed former solid propellant test cell where solvents used to clean rocket motors and hardware; solvents reportedly not recycled and disposed of by dumping into nearby drains and sumps.
31	12(?) 107, 112	No Yes	Asphalt paved driveway.	Both buildings contained propellant test cells; solid propellants may have been used during early history of buildings, along with solvents associated with solid propellant clean up. Building 107 later converted to plasma flow research laboratory. Implications are similar to the same rationale for boring reference No. 19.
32	86	Yes	Under walkway at top of steep slope on south side of Building 86.	Seepage pit near east end of solid propellant preparation area and adjacent to Building 86; pits (sumps) in area reportedly used to dispose of solvents.

TABLE 5-17

(Continued)

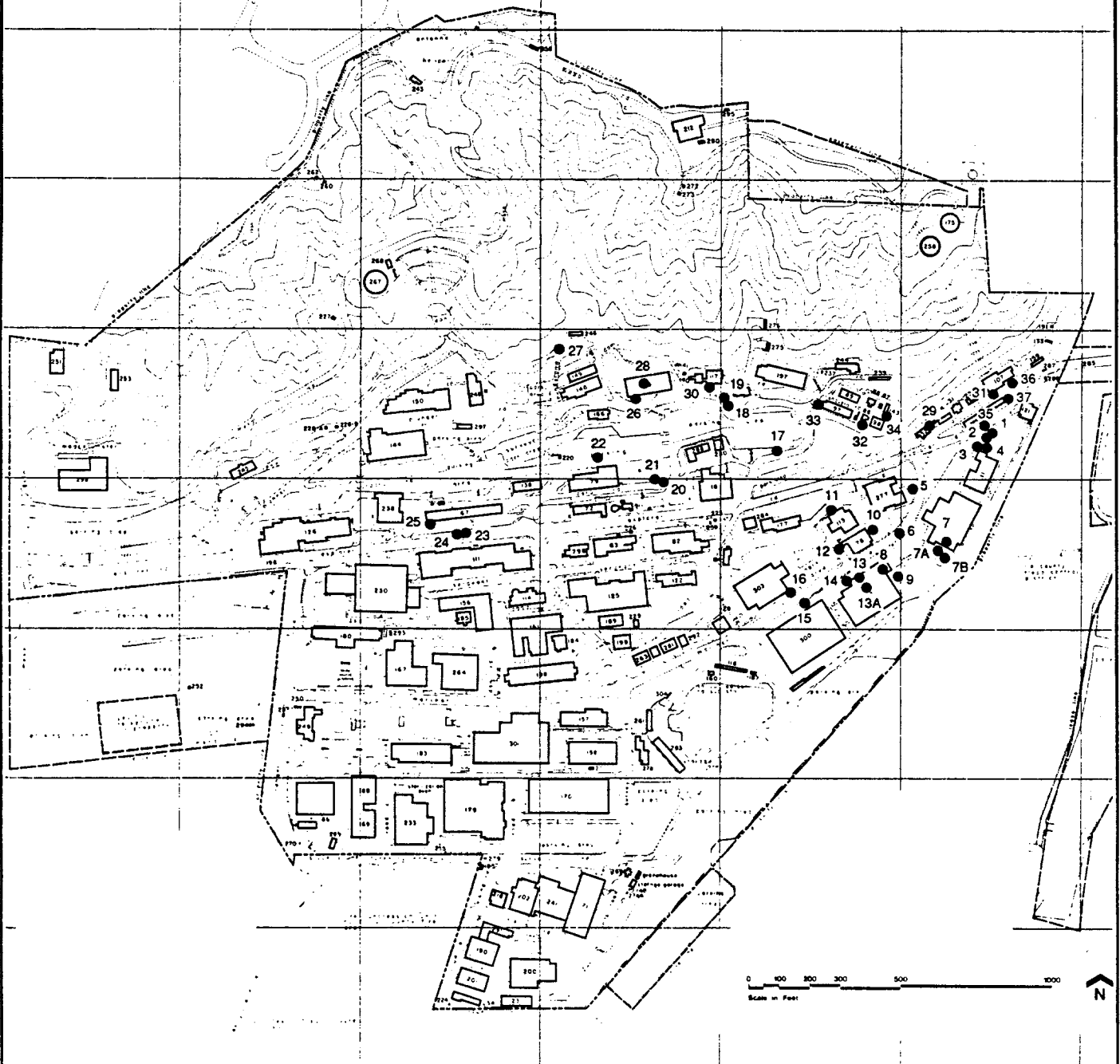
Seepage Pit No.	Associated Building No.	Building Still Exists (Yes/No)	Current Area Use	Inferred Use
33	97	Yes	Asphalt paved driveway.	Development laboratory for solid propellant chemistry experimentation; solvents used to clean laboratory hardware; all sink drains led to seepage pit; a sump or dry well at west end of building reportedly used for solvent disposal.
34	98	Yes	Asphalt paved driveway.	Seepage pit at east end of solid propellant preparation area (Buildings 86, 87, 88, 89, and 98); pit reportedly used for disposal of carbon tetrachloride, methyl ethyl ketone, trichloroethylene, cyclohexanone (?), and other chemicals after sewer system installed.
35	81	No	Asphalt paved parking lot.	Building housed workshops, storage rooms, and offices. Seepage pit located in same area where solvents and other chemicals discovered in soil during ongoing construction. (See rationale for boring reference Nos. 19 and 20.)
36	Unknown		Asphalt paved driveway.	Storm drain catch basins removed during ongoing construction were contaminated with carbon tetrachloride, acetone, chloroform, trichloroethylene, and mercury; sump tanks (leakages reported), dilution chambers, and seepage pits, associated with test cells and shops, existed along north side of Jato Road).
37 (DW)	2	No	Under Explorer Road.	Dry well for drain from building has unknown use, but implications are same as those for Seepage Pit Nos. 1, 2, 3, 4, 35, and 36.
NA	197	Yes	Asphalt paved driveway.	1,000-gallon tank (possible leakage) located at west end of building; propellant grindings and solvents reportedly dumped into tank at frequent intervals.

NA - Not applicable

DW - Dry well

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY
SITE PLAN · FACILITY LOCATIONS



LEGEND
12 ● Seepage Pit or Dry Well
Location and Number
(approximate Locations)

Figure 5 - 16
**Locations of Known
Seepage Pits and Dry Wells**

a limited soil gas study, a limited soil boring study, and the groundwater well installations were completed. This is discussed in Section 5.2.

5.1.13 Maness Environmental Services, Inc. (1992)

In August 1991, during the excavation for the Optical Instruments Laboratory's (Building 306) foundations and bottom floor, the construction contractor, Kitchell Contractors, Inc., encountered a layer of soil that appeared to be contaminated with petroleum hydrocarbons. Maness Environmental Services, Inc. (MES) was retained to evaluate the extent of the contaminated soil and determine the most cost- and time-effective method for remediating the site.

It was initially estimated that the amount of contaminated soil encountered ranged between 50 to 100 cubic yards (cu yd). However, after MES began their excavation in the impacted area, it became apparent that there was more contaminated soil than originally estimated. Fourteen soil samples were collected from MES's excavation in the most visually stained areas and analyzed for total recoverable petroleum hydrocarbons (TRPH) by EPA Method 418.1. TRPH concentrations in these samples ranged from a low of 38 milligrams per kilogram (mg/kg) to a high of 3,000 mg/kg and averaged about 700 mg/kg. Since the source of contamination was unknown, and other materials (e.g., shrubs, trees and tree stumps, railroad ties, piping, broken concrete, etc.) had been removed from a gully occupying part of the site, five samples were composited in the laboratory and analyzed for TRPH by EPA Method 418.1, volatile organic compounds (VOCs) by EPA Method 8240, semi-volatile organic compounds (SVOCs) by EPA Method 8270, pesticides and PCBs by EPA Method 8080A, California Administrative Code Title 26 metals by EPA Methods 6010/7000 series, cyanide by EPA Method 335.2, and toxicity characteristic leachate potential (TCLP) for purgeable organics (8240) and semi-volatiles (8270). In addition, a bioassay toxicity test was conducted on the composite sample to determine whether the contaminated soil is hazardous in accordance with Title 22 of the California Administrative Code. Results of these analyses performed on the composite sample are summarized in Table 5-18.

Based on the results of these analyses, the contaminated soil at the construction site was determined to be non-hazardous in accordance with Title 22 criteria. Most of the contamination appeared to be comprised of heavy-end petroleum hydrocarbons from unknown sources. Based on the other types of debris found in the contaminated soil, the gully is believed to have served as a local dumping area prior to NASA acquiring the property.

Since these initial explorations indicated that the contamination was deeper than anticipated, a limited soil-boring program (six hollow stem auger borings) was conducted to evaluate the

TABLE 5-18**ANALYTICAL RESULTS FOR CONTAMINANT CHARACTERIZATION,
COMPOSITE SOIL SAMPLE FROM BUILDING 306 EXCAVATION**

Analysis	Concentration (mg/kg)	EPA Method
Total petroleum hydrocarbons	180	418.1
Volatile organic compounds	ND	8240
Semi-volatile organic compounds	ND	8270
Pesticides and PCBs	ND	8080A
Cyanide	ND	335.2
Title 22 Metals:		
Antimony	0.95	6010
Arsenic	0.22	7060
Barium	120	6010
Beryllium	0.58	6010
Cadmium	ND	6010
Chromium	11	6010
Cobalt	11	6010
Copper	30	6010
Lead	14	6010
Mercury	0.10	7471
Molybdenum	0.50	6010
Nickel	8.1	6010
Silver	ND	6010
Thallium	ND	6010
Vanadium	43	6010
Zinc	66	6010
TCLP volatile organics	ND	8240
TCLP semi-volatile organics	ND	8270
Bioassay toxicity test	Non-Hazardous	

mg/kg - Milligrams per kilogram.

ND - Not detected.

vertical and lateral extent of the contamination east of the west soldier-pile wall. Soil samples were collected with a split-spoon sampler using brass sleeves at depths of 3, 5, 10, 15, and 20 feet, and they were analyzed for TRPH by a mobile laboratory on the site. If the samples contained TRPH concentrations of 50 milligrams per kilogram (mg/kg) or greater, the samples were also analyzed for aromatic volatiles (benzene, toluene, ethylbenzene, and total xylenes) by EPA Method 8020 and California Department of Health Services Method 8015 modified for diesel fuel.

Elevated concentrations of TRPH ranging from 21 to 5,500 mg/kg at an average depth of about 5 feet were found in the six borings. The sample that contained 5,500 mg/kg TRPH also contained 94 mg/kg of diesel; aromatic volatiles were not detected in any of the samples collected from these borings. Because of the unexpected levels of contamination encountered in the 6 borings, an additional 24 soil borings were drilled and sampled in a grid pattern over the construction site within the footprint of Building 306 (Figure 5-17). The same sampling and analysis rationale was followed for the additional borings with the exception that the next sampling depth in a boring would not be sampled if the sample above the depth contained less than 50 mg/kg TRPH.

Based on the results of this sampling and analysis program, it was determined that soil contaminated with petroleum hydrocarbons existed to an average depth of 5 feet throughout the entire building construction site on the east side of the west soldier-pile wall. Soil samples were not collected from the west side of the wall. Eighty-four samples were analyzed for TRPH and 33 were analyzed for diesel and BTEX. Results of these analyses are presented in Table 5-19.

Similar to the soil boring and sampling program, the stockpiles of soil materials excavated during initial construction were investigated using hand-auger and hammer-drive techniques to obtain discrete samples. These samples were analyzed for TRPH, diesel and BTEX using the same rationale as for the samples collected during the soil boring program. Results of these analyses also indicated elevated levels of heavy-end petroleum hydrocarbons with traces of diesel fuel and no detectable concentrations of gasoline.

Following the general profiling of the contaminated soils that still needed to be excavated and those contained in the stockpiles, more than 150 screening samples were analyzed during their removal and transportation to a suitable Class II or Class III landfill. The Los Angeles Regional Water Quality Control Board requirements stipulate that the maximum acceptable levels for discharge into a Class III landfill for soils impacted with waste oil, crude oil, or diesel fuel is 1,000 mg/kg TRPH. For soils impacted with gasoline, the maximum acceptance level is 100 mg/kg TRPH, 0.07 mg/kg benzene, 10.0 mg/kg toluene, 68.0 mg/kg ethylbenzene, and

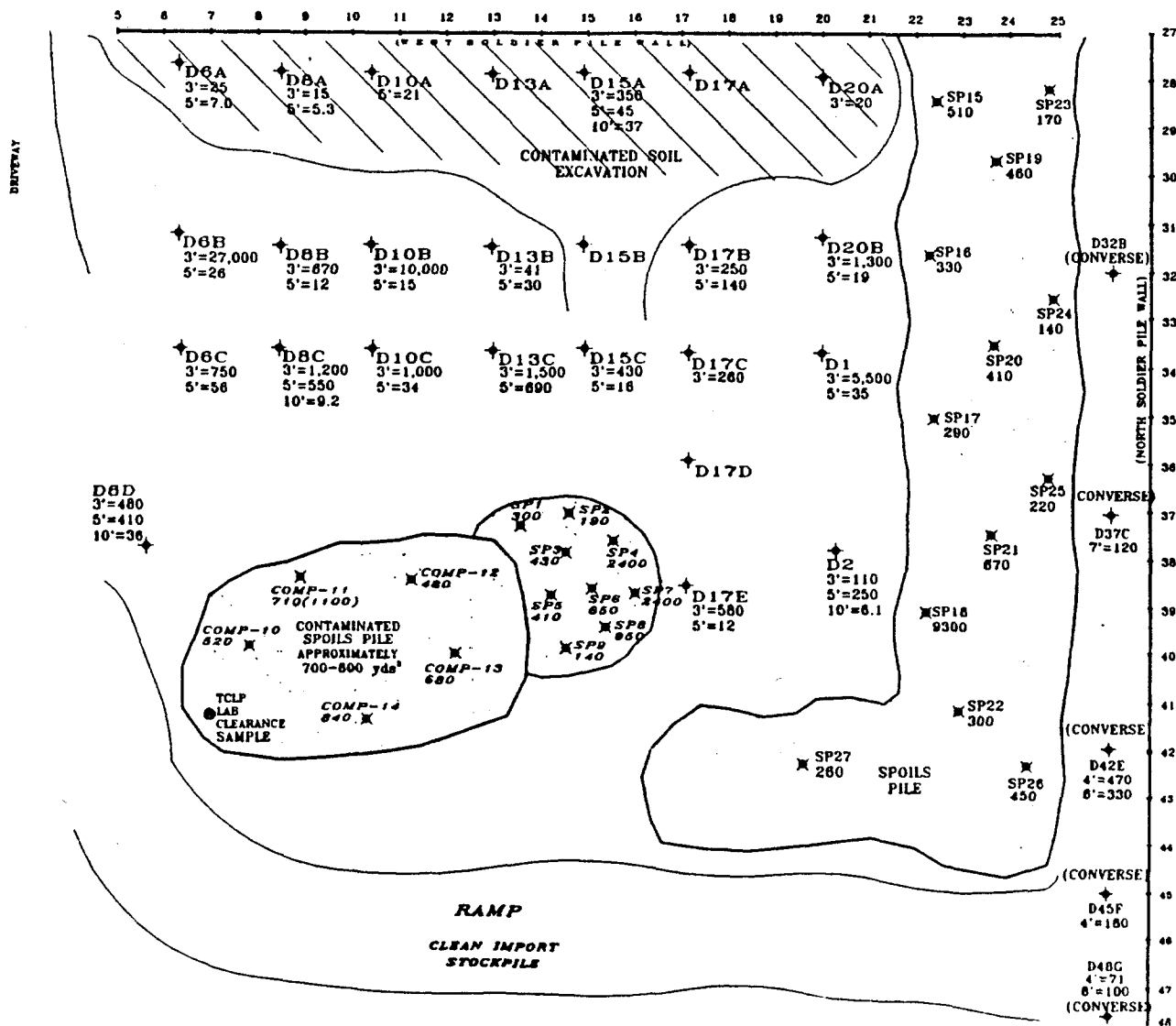


Figure 5 - 17

**Boring and Sampling Locations
In Building 306 Excavation**

Reference: Maness, 1992.

Table 5 - 19

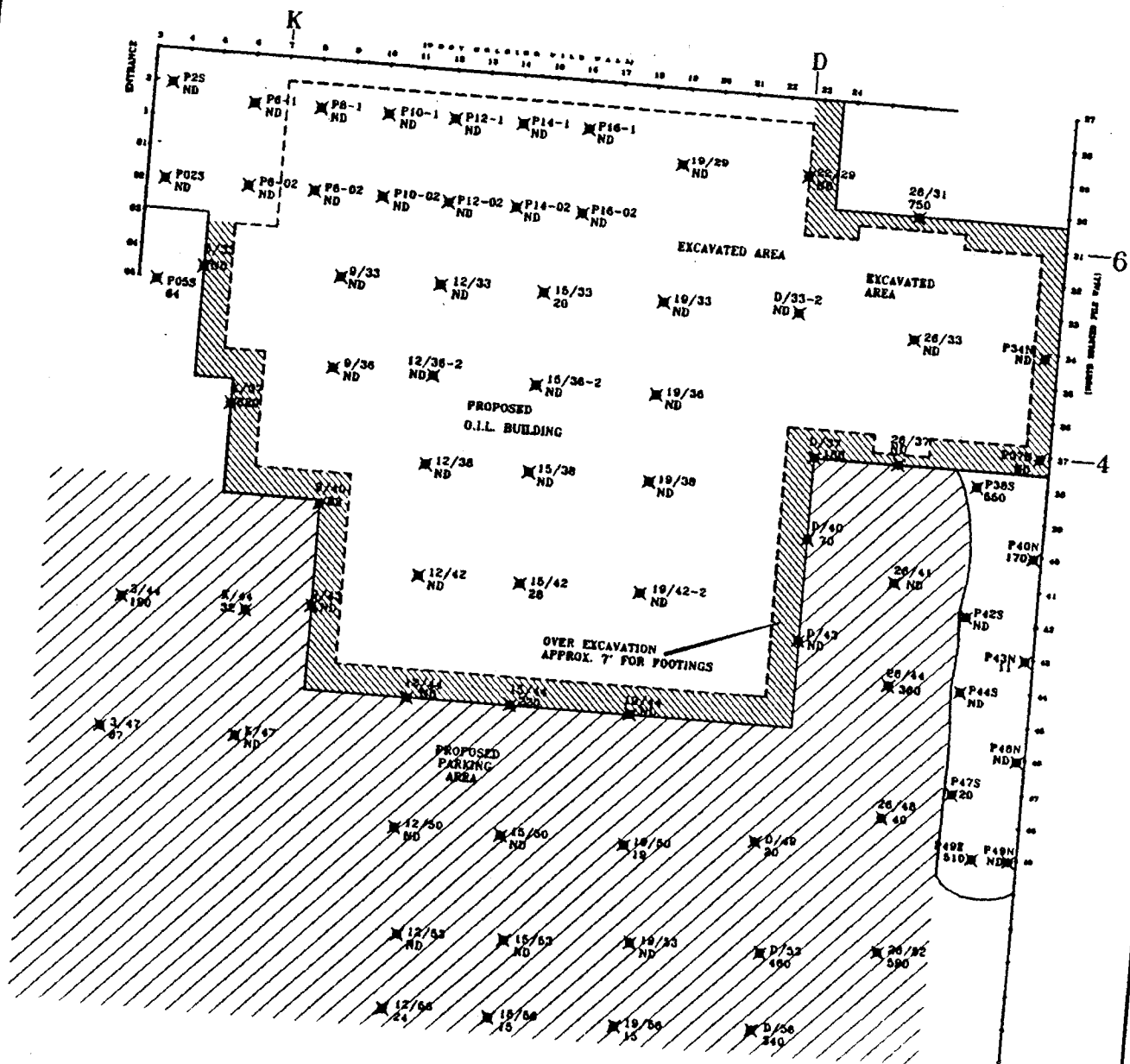
Analytical Results for Soil Test-Boring Investigation

SAMPLE ID	EPA 418.1	8015 M DIESEL	EPA 8020/BTEX
D 6 A - 3'	25	-	-
D 6 A - 5'	7	-	-
D 6 B - 3'	27,000	140	ND
D 6 B - 5'	26	-	-
D 6 C - 3'	750	ND	ND (*)
D 6 C - 5'	56	ND	ND
D 6 C - 10'	ND	-	-
D 6 D - 3'	480	ND	ND
D 6 D - 5'	410	ND	ND
D 6 D - 10'	36	-	-
D 8 A - 3'	15	-	-
D 8 A - 5'	5.3	-	-
D 8 B - 3'	670	ND	ND
D 8 B - 5'	12	-	-
D 8 C - 3'	1,200	ND	ND (**)
D 8 C - 5'	550	ND	ND
D 8 C - 10'	9.2	-	-
D 10 A - 3'	ND	ND	ND
D 10 A - 5'	21	ND	ND
D 10 A - 10'	ND	-	-
D 10 A - 15'	ND	-	-
D 10 A - 20'	ND	-	-
D 10 B - 3'	10,000	99	ND
D 10 B - 5'	15	-	-
D 10 C - 3'	1,000	ND	ND
D 10 C - 5'	34	-	-
D 13 A - 3'	ND	ND	ND
D 13 A - 5'	ND	ND	ND
D 13 A - 10'	ND	-	-
D 13 A - 15'	ND	-	-
D 13 A - 20'	ND	-	-
D 13 B - 3'	41	-	-
D 13 B - 5'	30	-	-
D 13 C - 3'	1,500	ND	ND
Detection Limit	5.0 mg/kg	20 mg/kg	0.1 mg/kg

SAMPLE ID	EPA 418.1	8015 M DIESEL	EPA 8020/BTEX
D 13 C - 5'	690	ND	ND
D 13 C - 10'	ND	-	-
D 15 A - 3'	300	ND	ND
D 15 A - 5'	43	ND	ND
D 15 A - 10'	37	-	-
D 15 A - 15'	ND	-	-
D 15 A - 20'	ND	-	-
D 15 B - 3'	ND	-	-
D 15 B - 5'	ND	-	-
D 15 C - 3'	430	ND	ND
D 15 C - 5'	16	-	-
D 17 A - 3'	ND	ND	ND
D 17 A - 5'	ND	ND	ND
D 17 A - 10'	ND	-	-
D 17 A - 15'	ND	-	-
D 17 A - 20'	ND	-	-
D 17 B - 3'	250	ND	ND
D 17 B - 5'	140	ND	ND
D 17 B - 10'	ND	-	-
D 17 C - 3'	260	ND	ND
D 17 C - 5'	ND	-	-
D 17 D	NR	NR	NR
D 17 E - 3'	580	ND	ND
D 17 E - 5'	12	-	-
D 20 A - 3'	20	-	-
D 20 A - 5'	ND	-	-
D 20 B - 3'	1,300	ND	ND
D 20 B - 5'	19	-	-
D 1 - 3'	5,500	94	ND
D 1 - 5'	ND	ND	ND
D 1 - 10'	ND	-	-
D 1 - 15'	ND	-	-
D 2 - 3'	110	ND	ND
D 2 - 5'	250	ND	ND
D 2 - 10'	6.1	-	-
D 2 - 15'	ND	-	-
Detection Limit	5.0 mg/kg	20 mg/kg	0.1 mg/kg

SAMPLE ID	EPA 418.1	8015 M DIESEL	EPA 8020/BTEX
D32B E-1 3'-4'	ND	-	-
D32B E-2 8'-9'	ND	-	-
D32B E-3 13'-14'	ND	-	-
D37C E-1 6'-7'	120	-	-
D37C E-2 10'-11'	ND	-	-
D37C E-3 19'-20'	ND	-	-
D42E E-1 3'-4'	470	ND	ND
D42E E-2 5'-6'	330	ND	ND
D42E E-3 9'-10'	ND	-	-
D45F E-1 3'-4'	180	ND	ND
D45F E-2 7'-8'	ND	-	-
D45F E-3 13'-14'	ND	-	-
D48G E-1 3'-4'	71	-	-
D48G E-2 7'-8'	100	-	-
D48G E-3 12'-13'	ND	-	-
Detection Limit	10 mg/kg	10 mg/kg	0.005 mg/kg (BTE) 0.015 mg/kg (X)

NOTE
ND = none detected
NR = no sample recovery
- = not analyzed
mg/kg = milligram per kilogram
BTEX = benzene, toluene, ethylbenzene, total xylenes
(*) = 0.15 mg/kg toluene
(**) = 0.1 mg/kg toluene



LEGEND

★ Sample Location and Number
TRPH Concentrations in mg/kg

0 25 50
APPROXIMATE SCALE IN FEET



Figure 5 - 18

Confirmation Sampling
Locations and Results

Reference: Maness, 1992.

- Time, money and data availability
- Analytic versus numeric

Selection Criteria

The dimensionality of a model influences its capability to simulate the natural system occurring at a particular site. Based on the subsurface stratigraphy at JPL, the vertical variation of contaminant concentrations in the groundwater, and the physical hydrogeologic characteristics of the aquifer, it was concluded that the site conditions indicate that a three-dimensional model is preferred for the following reasons:

- Three-dimensional models inherently are more likely to capture the appropriate physical processes as vertical averaging of contaminant concentrations is not performed.
- A three-dimensional model may enable a more accurate identification of potential sources using observed vertically varying levels of contamination.
- A three-dimensional model can potentially be more accurate for evaluating remedial pumping alternatives in terms of selecting both horizontal spacing between wells and elevations of screens for optimal plume capture.

In general, finite-difference models are conceptually simpler and more efficient to operate than a finite-element program. However, finite-element models have the advantage that their grids can be adjusted to fit complex stratigraphy (both horizontally and vertically), and can be configured more efficiently to adapt to areas with high gradients, such as around pumping wells during remediation. Also, finite-difference models can be vertically less accurate than finite-element models.

Most models available for selection can simulate either dynamic or steady-state conditions. However, fully dynamic solutions can be very computer intensive and costly. If the water table conditions are relatively constant, a steady-state solution may provide an adequate description of the groundwater flow for subsequent mass transport simulations. However, if there are distinct water-table variations, such as the seasonal variations that occur at JPL, it may be possible to treat each season as a steady-state event over its duration and model mass transport using a series of steady-state flow conditions of the appropriate duration. Thus, the selected model should be able to simulate both steady-state and transient conditions.

At the JPL site, the detected contaminants are in the saturated zone (water-table aquifer). Potential sources are best assessed by assuming vertical migration downward through the unsaturated zone from spill locations, which is usually sufficient for the needs of groundwater

remediation analyses. Therefore, it was concluded that a saturated, unconfined water-table program would be adequate to model the groundwater flows beneath the JPL site.

Contaminants detected in downgradient wells include TCE, PCE, and CCl_4 . Concentrations of the observed TCE, PCE, and CCl_4 in the aquifer suggest that they are not being transported as a dense non-aqueous phase liquid (DNAPL) since these contaminants have not been detected in the lowest screened intervals of the existing deep multi-port wells MW-3, MW-4, and MW-11. If a DNAPL plume was present beneath the site, it would be expected that a dissolved-phase contaminant plume, originating from the DNAPL plume, would be detected in the lowest screened interval in these wells. If this assumption is valid, then the transport and fate processes that should be simulated are advections, dispersivity, decay, retardation, and sources and sinks. The mass transport model selected should be capable of simulating these physical processes.

A stated requirement of the model-selection process, the model(s) selected must be readily available and widely used in the public domain. These models should be available through the government agency that developed the model (e.g., the USGS or EPA), through a clearing house such as the International Groundwater Modeling Center (IGWMC), or readily available through the model developer (e.g., individual, consulting company, or university). Only those models developed in the United States were considered.

The major objective of the modeling process is to evaluate the mass transport of contaminants in the study area. Therefore, a single model may be selected that includes mass-transport routines, or a suite of models could be used that include both a groundwater-flow program and a compatible mass-transport program. This requirement eliminates the efforts of reprogramming and revalidation of the models.

Model Comparisons

The aim of the available-model review was to select a groundwater-flow program and a compatible mass-transport program that are in common usage and having strong histories of applications that demonstrate sound formulation and flexibility to address multiple uses. During the past several years, both the USGS and EPA have published the following major review reports on available groundwater modeling programs.

- EPA (1988c), "Groundwater Modeling: An Overview and Status Report."
- EPA (1990), "Report on the Usage of Computer Models in Hazardous Waste/ Superfund Programs."

- USGS (1988), "Selected Reports that Include Computer Programs Produced by the U.S. Geological Survey for Simulation of Ground-Water Flow and Quality."
- USGS (1991), An update to USGS (1988)

Approximately 200 different models (including those for saturated and variably-saturated flow programs, and mass transport programs) were reviewed and discussed in these publications. Because of the large number of programs, only those considered to be "widely used" by "many" under the category of model users, were selected for further comparison. In addition, all of the mass-transport programs considered included model advection, dispersivity, decay, and retardation.

Following the initial screening, only 15 groundwater flow simulation models remained for further comparison and evaluation. Final selection criteria included the answers to the following six basic questions:

- Is the model readily available in the public domain?
- Is the model widely used by many?
- What is the ease and efficiency of the model (a reflection of the model's cost benefit)?
- Is the model two or three dimensional?
- Does the flow model have a compatible mass-transport program?
- Can the model be run in both steady-state and transient modes?

Answers to these questions for the 15 candidate programs narrowed the selection process to those listed in Table 5-20, in which relative comparisons of availability, usage, documentation, limitations, cost, and other features are tabulated.

Recommended Selection

The review of candidate groundwater-flow and mass-transport models suggests that the following two suites of programs merit further consideration:

- MODFLOW and RAN3D or MT3D
- DYNFLOW and DYNTRACK

MODFLOW is a three-dimensional, finite-difference program, that is in the public domain, relatively easy and efficient to use, and in common usage. RAN3D and MT3D are available mass-transport programs that are compatible with MODFLOW. However, RAN3D has been

TABLE 5-20

COMPARISON OF PROGRAM FEATURES

Code Name	Source	Cost	Type and Numerics	Public Availability	Documentation	Previous Use Acceptance	Compatability	Limitation
MODFLOW	USGS	\$0-\$395	F-D Flow Direct solution	Yes	Good	Many	Good	Few
MT3D	Papadopolus & Assoc.	Small	F-D Mass Direct solution	Yes	Good	Limited	Good	Technically few
RAN3D	Prickett; Engineering Technology, Inc.	Small	F-D Mass Particle Tracking	Yes	Good	Moderate	Good	Few
PLASM	Prickett	Small	F-D Flow Direct solution	Yes	Good	Many	Good	2-D program
PLASM3D	Prickett	Small	F-D Flow Direct solution	Yes	Limited	Few	Good	Limited use
DYNEFLOW	Camp Dresser & McKee	Note 1	F-E Flow Direct solution	Yes	Good	Moderate ²	Good	Few
DYNTRACK	Camp Dresser & McKee	Note 1	F-E Mass Particle Tracking	Yes ¹	Good	Moderate ²	Good	Few
CFEST	Battelle PNL	Moderate	F-E Flow and Mass Direct solution	Yes	Good	Moderate	Good	Overly complex, needs large computer

TABLE 5-20

**COMPARISON OF PROGRAM FEATURES
(Continued)**

Code Name	Parameters	Graphical Output	Output Format	Computer Requirements	Cost per Unit Run	Comments
MODFLOW	Transmissivity Leakances	MODPLOT	Tabular	386	Small	The most widely used flow program
MT3D	Dispersivity Decay rate Retardation (Kd) Porosity	Yes	Tabular	386	Small	Limited use so far
RAN3D	Dispersivity Decay rate Retardation (Kd) Porosity	Yes	Tabular	386	Small	Best proven mass transport model for MODFLOW
PLASM	Transmissivity	Yes	Tabular	386	Small	2-D program but widely used
PLASM3D	Transmissivity Leakances	Yes	Tabular	386	Small	Limited use, Prickett uses MODFLOW
DYNEFLOW	Conductivities	DYNPLOT ³	Postprocessor Tabular	386 VAX SUN	Moderate	Relatively easy to use for finite-element program
DYNTRACK	Dispersivity Decay rate Retardation Porosity	DYNPLOT ³	Postprocessor Tabular	386 VAX SUN	Moderate	Relatively easy to use for finite-element program
CFEST	Conductivities Dispersivity Decay rate Retardation (Kd) Porosity	Yes	Tabular	CRAY Other large machine	High	Overly complex, needs large computer

Notes:

¹ Currently for sale at about \$5000/program. May soon be available through IGWMC.² Limited to Camp, Dresser & McKee and some universities.³ DYNPLOT can be purchased at about \$5000. Will not be released through IGWMC.

more widely used, and it uses particle tracking to simulate advection and dispersion (an inherently more accurate approach than direct solutions).

DYNFLOW and DYNTRACK are the best selection of three-dimensional, finite-element programs for the study area. These proprietary models are currently costly and bound by license restrictions, and are somewhat less efficient to use.

It was recommended that the MODFLOW and RAN3D programs be selected and used in the JPL study for the following reasons:

1. MODFLOW is relatively easy to use and is the most widely used program.
2. MODFLOW is in the public domain and has a variety of support programs for pre- and post-processing.
3. EPA has expressed a preference for non-proprietary models in the public domain.
4. MODFLOW is considered to be a "proven" program, whereas DYNFLOW is not in common usage.
5. MODFLOW has the features and spatial flexibility to simulate conditions at JPL.
6. RAN3D is a compatible mass-transport model that is in the public domain and uses a highly accurate particle-tracking scheme.

The early selection of groundwater-flow and compatible mass-transport models, which must accurately and efficiently simulate JPL's site conditions, is important to the CERCLA process so that data collected will be applicable and adequate for the evaluation of remedial alternatives.

5.2 PRE-RI INVESTIGATION

In anticipation of being placed on the National Priorities List (NPL) by the EPA, a phased pre-RI investigation was initiated to begin subsurface explorations at potential contaminant sources originating at seepage pit locations identified earlier (see Section 5.1.11), and to obtain additional information on the lateral and vertical extent of volatile organic compounds in the groundwater. During these explorations, three shallow monitoring wells were installed by Ebasco Environmental (Ebasco) to characterize the horizontal extent, and one deep multi-port monitoring well was installed by Ebasco to further characterize the vertical extent of contaminants in the groundwater below JPL.

Of particular importance during the pre-RI investigation was a pilot study involving a shallow soil gas survey and a soil boring and sampling program. A shallow soil gas survey was conducted at nine potential contaminant source areas. The results were compiled and a boring was drilled and soil samples collected at the five seepage pit locations that had the highest

concentrations of volatile organic compounds. Analytical results were used to evaluate the use of soil gas sampling in locating or characterizing potential contaminant source areas at JPL in a cost-effective manner. The field program completed for the pre-RI investigations and the results obtained are described in the following sections.

5.2.1 Soil Gas Survey Sampling and Analysis

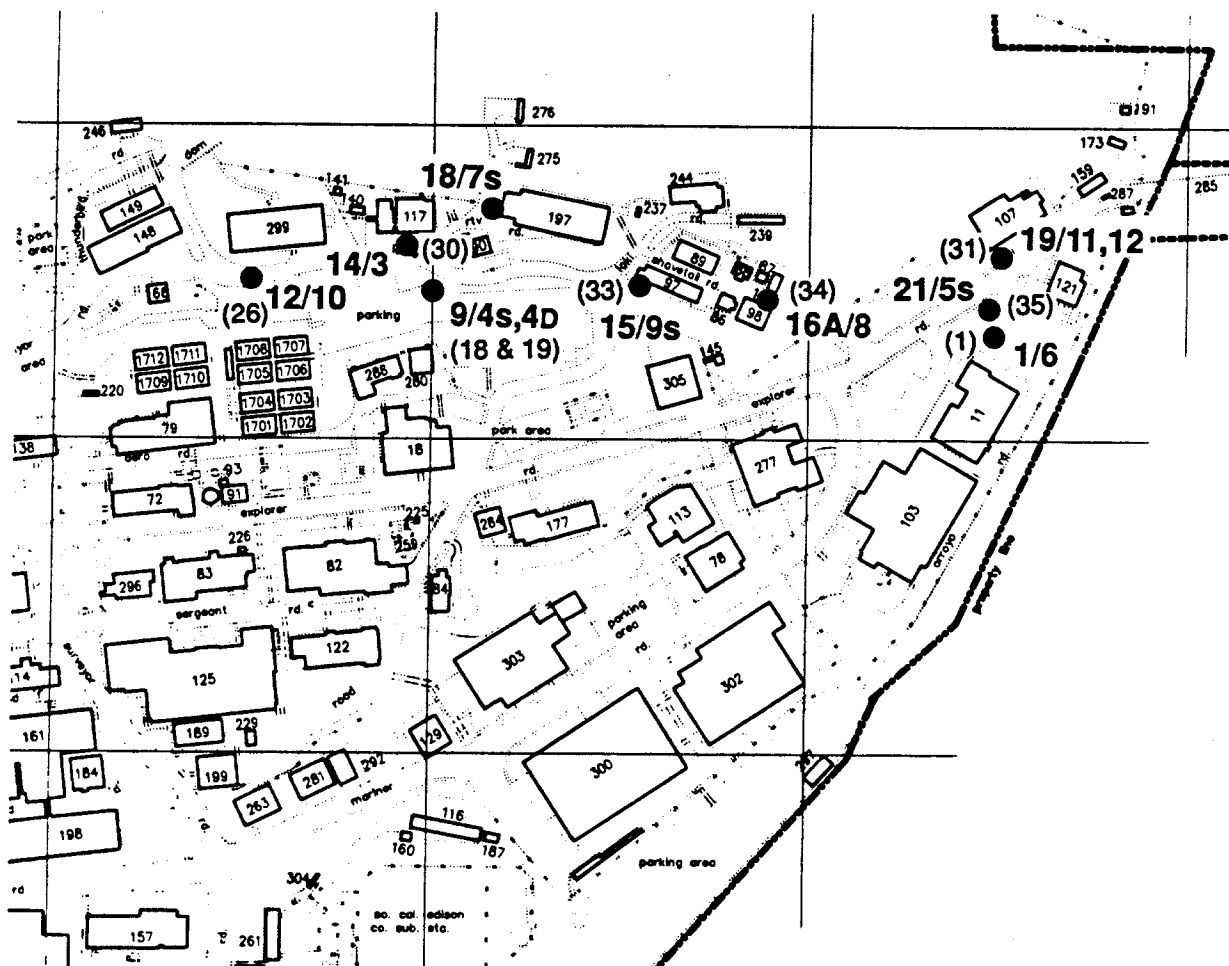
Following the completion of the initial draft RI/FS work plan (Ebasco, 1991), it was decided to conduct a pilot soil gas program at selected seepage pit locations to evaluate whether or not active soil gas sampling could be used as a cost-effective tool to verify the location of some of the seepage pits. Five seepage pit locations (Nos. 1, 30, 31, 34, and 35) were selected for soil gas sampling based on their potential for having contained solvents or petroleum compounds during their historic use. It was planned that the five selected seepage pit locations would be probed and sampled during a 1-day effort. If time allowed, other seepage pit locations would also be sampled. The target depth for each sample was 30 feet with an intermediate sample to be collected between 15 to 20 feet. However, a sample would be collected at probe refusal no matter what the depth might be.

On April 7, 1992, soil gas samples were collected at the five selected seepage pits plus three other seepage pit locations and one proposed soil boring (SB) location. The soil boring locations included SB9 (located downslope from Seepage Pit Nos. 18 and 19), SB12 (at Seepage Pit No. 26), SB15 (at Seepage Pit No. 33), and SB18 (at the west end of Building 197). Soil gas sample locations are shown in Figure 5-19. Probe refusal, caused by competent subsurface lithology encountered, resulted with soil gas samples being collected between 6 and 30 feet. Actual sample depths obtained for each location is presented in Table 5-21.

All of the soil gas samples collected were subjected to two analyses. The first analysis was conducted according to EPA Method 601 (modified) using direct injection into a gas chromatograph equipped with an electron capture detector.

Specific volatile organic compounds standardized for this analysis are listed below. The chlorinated hydrocarbons in this suite were chosen because of their common use in industrial solvents and their degradational relationship to commonly used compounds.

- 1,1-dichloroethene (1,1-DCE)
- Methylene chloride (CH_2Cl_2)
- trans-1,2-dichloroethene (t-1,2-DCE)
- 1,1-dichloroethane (1,1-DCA)



Scale in feet



Legend

- 1/6 - Soil Boring Number/Soil Gas Sample Number
- (1) - Seepage Pit Numbers are in Parentheses

Figure 5 - 19

Soil Gas Sampling Locations

TABLE 5-21

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL GAS SAMPLES

Seepage Pit Number	Proposed Soil Boring Number	Soil Gas Sample Number	Sample Depth (feet)	Carbon tetrachloride	Chloroform	1,1- dichloroethene	1,1,1- trichloroethane	Trichloro- ethylene
				Concentrations in micrograms per liter ($\mu\text{g/l}$)				
1	1	6	10.5	54	1.0	1.5	ND	ND
18,19	9	4S	20	ND	ND	29	ND	ND
	9	4D	30	ND	ND	44	ND	ND
26	12	10	10.5	ND	ND	4.6	ND	ND
30	14	3	27-30	ND	ND	1.4	ND	ND
33	15	9S	20	ND	ND	1.2	ND	ND
34	16A	8	6	ND	ND	ND	1.5	ND
NA	18	7S	21-24	ND	ND	ND	ND	ND
31	19	11	12	7,928	20	ND	ND	2.2
	19	11	19	5,076	17	ND	ND	1.4
35	21	5S	15	218	2.7	1.4	ND	ND

ND - Not detected (or below detection limit of 1.0 $\mu\text{g/l}$).

NA - Not applicable.

- cis-1,2-dichloroethene (c-1,2-DCE)
- Chloroform (CHCl₃)
- 1,1,1-trichloroethane (1,1,1-TCA)
- Carbon tetrachloride (CCl₄)
- Trichloroethene (TCE)
- 1,1,2-trichloroethane (1,1,2-TCA)
- Tetrachloroethene (PCE)

In addition, the chromatograms were scanned in the analytical laboratory for the presence of vinyl chloride. The laboratory reported that vinyl chloride was not present at concentrations greater than the detection limit of 10 micrograms per liter ($\mu\text{g/l}$).

The second analysis was conducted according to EPA Method 602 (modified) using direct injection into a gas chromatograph equipped with a flame-ionization detector (FID). The analytes for this method were:

- Benzene
- Toluene
- Ethylbenzene
- Meta- and para-xylene
- Ortho-xylene

A summary of the volatile organic compounds (EPA Method 601) detected in the soil gas samples is presented in Table 5-21. Petroleum-based hydrocarbons (EPA Method 602) were not detected in any of the samples.

Based on the results of the soil gas analyses, it is recommended that all seepage pit locations and other areas of suspected waste disposal be screened for VOCs prior to drilling and sampling.

5.2.2 Soil Investigation

Results generated from the soil gas survey (Section 5.2.1) were used to determine which of five seepage pits and four proposed soil boring locations sampled would be further investigated as part of the pilot study. Soil samples were proposed to be collected from five locations with the highest VOC concentrations in the soil gas samples. Subsequently, borings were drilled and soil samples collected for laboratory analysis from seepage pit location Nos. 1, 18, 26, 31, and 35.

Corresponding soil boring reference numbers are, respectively, SB1, 9, 12, 19, and 21 (Figure 5-19).

Drilling and Soil Sampling Procedures

Layne Environmental Services, Inc. was subcontracted to complete drilling activities for the soil sampling investigation at the seepage pit locations listed above. The drilling and sampling program was conducted from October 12 through October 18, 1992. Each soil boring was drilled with a dual-wall percussion drilling rig using reverse-air circulation to remove the soil cuttings from the borehole. Relatively undisturbed soil samples were collected for laboratory analysis at 10-foot intervals beginning at a depth of 10 feet below ground surface. Soil Borings 1, 9, 19, 21 were completed to a depth of 100 feet. Soil boring 12 was terminated at a depth of 88 feet because of mechanical problems associated with the drill rig's compressor. Soil samples were collected using a split-spoon sampler following the procedures described below.

- Drill to desired sampling depth.
- A split-spoon sampler containing three stainless steel sample tubes was lowered on a cable down through the middle of the dual-wall drive pipe to the sampling depth. The sampler was driven into the soil a minimum of 18 inches beyond the drill bit by a 140-pound sliding hammer with a 30-inch vertical stroke. Each of the three decontaminated sample tubes in the sampler were 6.0 inches long and 2.5 inches in outside diameter.
- After the sampler was retrieved, both ends and one-half of the split-spoon was removed to access the three sample tubes. The uppermost sample tube was used for lithologic description purposes, the middle tube for quality-control purposes (if required) and the lowermost tube for laboratory analysis. The ends of the soil sample designated for laboratory analysis were trimmed, covered with teflon sheets, and capped with tightly fitting plastic end caps. After the sample was labelled, it was sealed in a plastic bag and placed on ice in a cooler prior to transporting to the laboratory. Samples used for lithologic descriptions were monitored for the presence of organic vapors with a flame ionization detector (FID). This was completed for data acquisition purposes as well as for health and safety monitoring. Measured FID values were recorded on the field boring log forms.

In addition to the soil samples, duplicate soil samples were collected to check the reproducibility of the analytical procedures. One duplicate soil sample was collected for approximately every twenty soil samples. The duplicate sample was analyzed for the same parameters as the soil sample from the same sample run.

To check the quality of the decontamination procedures, an equipment blank was collected for approximately every ten soil samples. Following decontamination, deionized water was poured through the split-spoon sampler and collected in a sample bottle. The sample was analyzed for volatile organics using EPA Method 8240.

At the completion of each boring, all samples were entered onto a chain-of-custody form. The form accompanied the samples and field personnel to the laboratory following "Chain-of-Custody" procedures. The transporter signed the Chain-of-Custody form upon acceptance of the samples.

The drilling and sampling operations were supervised by an Ebasco Environmental geologist who maintained the log of borings, collected the soil samples, and visually classified the soils encountered according to the Unified Soil Classification System. Notations regarding other drilling and soil characteristics encountered (e.g, color changes, estimated relative moisture content, density, odor, etc.) were also recorded on the field boring log form. Logs of the soil borings are presented in Appendix A.

Prior to drilling each boring, all of the dual-wall drive pipe and ancillary down-hole drilling equipment were steam cleaned, including the annular space between the drive-pipe walls. The soil samplers and sample sleeves were washed in a mild Liquinox® cleaning solution, rinsed at least twice with deionized water, and air dried before use. Decontamination water generated by steam cleaning was collected within the bermed wash area and transferred into a Baker tank.

Soil cuttings generated during the drilling operations were placed in roll-off bins and stored at the south end of the east parking lot for later disposal. The method and location of disposal will depend on the results of laboratory analyses performed on the composite soil samples collected during drilling activities. Disposal methods will be pursuant to EPA's guidance on the management of investigation-derived wastes (EPA, 1991 and EPA, 1992a).

Upon completion of drilling and sampling of each boring, the borehole was backfilled with ¼-inch Enviroplug bentonite chips that were hydrated as they were being placed. The dual-wall drive pipe was used as a tremie during the backfilling procedure and was removed, one section at a time, while the bentonite chips were being added. Holes in the asphalt pavement were repaired with a cold-patch asphalt mixture.

Laboratory Testing Program

Soil samples collected from the borings were delivered to Montgomery Laboratories, a laboratory certified by the California Department of Health Services (CDHS Certification No.

1422), for chemical analysis. The analysis performed was dependent upon the depth within the borehole that each soil sample was collected (Table 5-22). Soil samples collected from the seepage pits were analyzed for volatile organics using EPA Method 8240 (including acetone, alcohols, and cyclohexanone). Soil samples collected from at the 30- and 60-foot depths were also analyzed for semi-volatile organics using EPA Method 8270, and for total petroleum hydrocarbons (TPH) using EPA Method 418.1. The soil samples collected at the 20-, 30-, and 60-foot depths were also analyzed for Title 22 metals (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, Se, Tl, V, Zn) and strontium using EPA Methods 6010/7000, and for mercury (Hg) using EPA Method 245.1. Cyanide was analyzed using EPA Method 9010. Additional analysis were total solids (EPA Method 160.3), laboratory pH (EPA Method 150.1), and nitrate (as N and NO₃) using EPA Method 300.0

5.2.3 Groundwater Investigation

The groundwater investigation, consisting of installing four monitoring wells, was designed to further define the nature and extent of contamination which exists within the groundwater beneath and downgradient from possible source areas at JPL. Locations of the four monitoring wells are presented in Figure 5-20. Monitoring wells MW-8, MW-9, and MW-11 were installed to further assess the areal extent of contamination in the eastern section of JPL. Monitoring well MW-10 was installed in the southwest corner of the site (upgradient of MW-5) to evaluate possible upgradient off-site contributions detected within the groundwater in existing well MW-5.

Installation of Shallow Wells

Three shallow monitoring wells (MW-8, MW-9, and MW-10) were installed between October 23 and October 31, 1992 at the locations shown in Figure 5-20. The shallow wells will be used to monitor the elevation of the water table and to sample for contaminants. They were constructed with 50 feet of stainless steel screen at the bottom of the well to compensate for large fluctuations in water-table elevations. Construction details for these shallow monitoring wells installed during the pre-RI work are listed in Table 5-23 and shown diagrammatically on construction logs included in Appendix B.

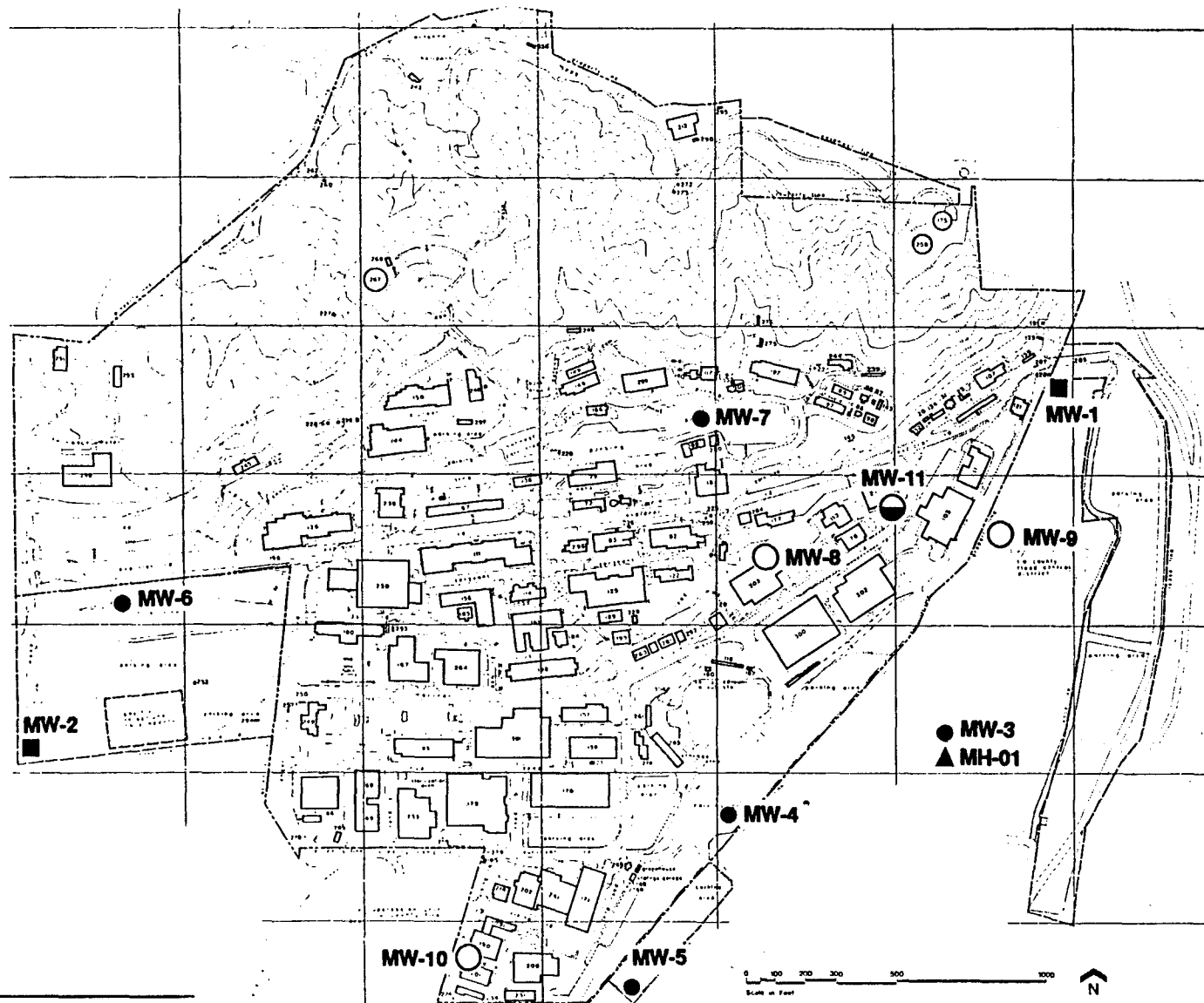
A Drill Systems AP-1000 dual-wall percussion drill rig with reverse air circulation was utilized for drilling and well installation purposes. The general procedures used during the installation of the shallow monitoring wells were as follows:

- Well depths were selected by the field geologist based on the location of the water table at the particular location.

TABLE 5-22
SEEPAGE PIT SOIL SAMPLE ANALYSES

Depth (feet)	VOCs EPA 8240*	Semi-VOCs EPA 8270	TPH EPA 418.1	Title 22 Metals and Strontium SW-846 6010/7000	Cyanide EPA 9010
10	X				
20	X			X	X
30	X	X	X	X	X
40	X			Archive	Archive
50	X			Archive	Archive
60	X	X	X	X	X
70	X			Archive	Archive
80	X			Archive	Archive
90	X			Archive	Archive
100	X			Archive	Archive

*Including Acetone and Alcohols plus Cyclohexanone.



LEGEND

- Pre-R1 Shallow Monitoring Wells
- Pre-R1 Deep Monitoring Well
- Installed during the ESI Investigation
- Installed by Geotechnical Consultants, Inc. in 1989
- ▲ Installed by Geotechnical Consultants, Inc. in 1982

Figure 5 - 20

**Locations of Groundwater
Monitoring Wells at Completion
of Pre-R1 Investigations**

TABLE 5-23

**CONSTRUCTION DETAILS FOR THE INTIAL PHASE
MONITORING WELLS**

Monitoring Well	Date Drilled	Drilling Method	Total Depth (feet)	Monitoring Well Diameter (inches)	Screened Interval (feet below grnd sfc)	Screen Slot Size (inches)	Well Material		Reference Point Elevation (feet above mean sea level)	Centralizers	Geophysical Survey
							Casing	Screen			
MW-8	10-29-92	Air Percussion Hammer	205	4	155-205	0.010	SS	SS	1139.53	No	Natural Gamma
MW-9	10-23-92	Air Percussion Hammer	68	4	18-68	0.010	Sch 40 PVC	SS	1106.02	No	Natural Gamma
MW-10	10-31-92	Air Percussion Hammer	155	4	105-155	0.010	PVC (0-85') SS (85'-105')	SS	1087.70	No	Natural Gamma
MW-11 (Deep Multi-Port Well)	11-17-92	Mud Rotary	680	4	1. 140-150 2. 250-260 3. 420-430 4. 515-525 5. 630-640	0.010	Carbon steel	SS	1139.31	Yes	Spontaneous Potential Short Normal Resistivity Long Normal Resistivity Single Point Resistivity Natural Gamma Caliper

SS - Stainless steel

- Upon completion of drilling, Welenco, Inc. (a geophysical well-logging subcontractor) performed a down-hole natural gamma ray survey (Appendix C). During the survey, the dual wall drive pipe was left in place.
- Fifty feet of 4-inch-diameter, stainless steel wire-wrap well screen with 0.010-inch slots and a bottom cap was lowered into each boring through the center of the dual-wall drive pipe. The slot size was selected based on sieve analyses completed during the Expanded Site Inspection (ESI) Ebasco, (1990a). Monitoring well MW-8 was constructed using 4-inch stainless steel casing above the screen. Polyvinyl chloride (PVC) with stainless steel transition blank casing was not used on the basis that the collective weight of the casing and screen associated with the depth of the wall may have been too great for the PVC threads and could cause separation during well construction. Monitoring well MW-9 was constructed with 4-inch, Schedule 40, PVC casing above the screen with no stainless steel transition blank casing due to the shallowness of the well. Monitoring well MW-10 was completed using 20 feet of 4-inch stainless steel transition blank casing above the screen followed by 4-inch, Schedule 40, PVC casing to surface. During the construction of each well, each joint of screen and casing was steam-cleaned and measured prior to installation.
- The annular space between the well screen and the boring wall was backfilled with clean, kiln-dried RMC Lonestar #2/12 sand. Sand was brought up to approximately 10 feet above the top of each screen, and the remaining annular space was filled with ¼-inch Enviroplug bentonite chips to form a seal. The dual-wall drive pipe was used as a tremie during backfilling and was removed one section at a time as the bentonite chips were being placed and hydrated.
- A locking monument cover and a steel and concrete traffic box were installed at monitoring wells MW-8 and MW-10. Each traffic box was installed just above grade to direct surface water runoff away from the well. A rising locking monument cover was used at monitoring well MW-9.

Development of Shallow Wells

Monitoring wells MW-8 and MW-10 were developed on December 29 and December 30, 1992, respectively. Monitoring well MW-9 could not be developed at that time because the access road to the monitoring well had been washed out during heavy winter rains. Monitoring well MW-9 was later developed on May 6, 1993, after the road was repaired.

The monitoring wells were initially developed by using a 2.5-gallon stainless steel bailer to remove sediment that had accumulated at the bottom of each well during well installation. Each well screen was subsequently swabbed with a rubber-disc swab tool to flush fine materials from the sand pack to restore the natural hydraulic conductivity of the formation and to stabilize the sand pack. Swabbing of each well was accomplished by swabbing progressive, discrete 3-foot intervals from the bottom of the well screen to the top of the water column.

With the completion of bailing and swabbing, a stainless steel submersible pump was lowered to the bottom of the well and pumped until the water being purged became clear. Then, the pump intake was raised and pumping resumed. The operation continued up through the water column until the entire submerged portion of the screened section had been pumped. Pumping continued until the physical (temperature, turbidity) and chemical parameters (specific conductance and pH) of the discharged water had stabilized and at least five well volumes of water had been produced. Occasionally, the pump was turned off to surge the formation.

Shallow Well Groundwater Sampling

Monitoring wells MW-8 and MW-10, along with the other shallow wells at JPL, were sampled in January 1993 as part of the periodic sampling program. Before sampling began at each well, the depth to groundwater was measured with an electronic water level meter. Each well was then purged with a 4-inch stainless steel submersible pump. The 4-inch submersible pump and discharge pipe used during purging were decontaminated prior to being used at each well by steam cleaning the interior and exterior surfaces of the pump and pipe. The pH, temperature, electrical conductivity, and turbidity of the discharge water were monitored using field instruments that were calibrated before and at the end of each day of sampling following equipment manufacturer's specifications. Purging continued until the pH, conductivity, and temperature of the purge water stabilized and the turbidity was less than five nephelometric turbidity units (NTU).

Water samples were collected with stainless steel and disposable teflon bailers. A stainless steel bailer was used to sample monitoring well MW-6. The stainless steel bailer was decontaminated prior to use by being thoroughly washed with a phosphate-free detergent and rinsed twice with deionized water. Disposable bailers were used to sample the remaining monitoring wells.

Installation and Development of the Deep Multi-Port Well

During the pre-RI investigations, an additional deep monitoring well (MW-11) was installed at the location shown in Figure 5-20. The multi-port (MP) sampling system was designed by Westbay Instruments Ltd. to collect discrete water samples within a vertical column using a single multi-screened well. During the Expanded Site Inspection (ESI), two such systems were installed in monitoring wells MW-3 and MW-4.

A Portadrill 10TLT-320 mud-rotary drilling rig was used to drill and install monitoring well MW-11. Before deep drilling began, a 16-inch-diameter, low-carbon steel surface conductor casing was installed to a depth of 26 feet and cemented in place. Drilling continued with a 10-inch-diameter bit to a total depth of 696.5 feet. During drilling operations, pure bentonite

drilling mud and hydrocarbon-free pipe dope were used. The drilling fluid was circulated out of the boring into a portable mud pit where the drill cuttings were separated from the drilling mud. Approximately 17,500 gallons of deionized water were used during drilling and installation of the casing and well screens.

Samples of soil cuttings were collected from just below the conductor casing and at 100-foot intervals below the ground surface. The samples were composited and analyzed by Montgomery Laboratories to evaluate proper disposal methods pursuant to EPA's guidance on the management of investigation-derived wastes (EPA, 1991 and 1992).

After drilling was completed, Welenco, Inc. obtained wireline geophysical logs for spontaneous potential, short normal resistivity, long normal resistivity, single point resistivity, natural gamma ray, and caliper log (Appendix C). The logs were used as an aid in evaluating the lithology of the subsurface materials and to select zones with apparently high hydraulic conductivity for well screen placement. The well was constructed with screened intervals opposite the inferred zones of relative high hydraulic conductivity.

The well casing (4-inch-diameter low-carbon blank) and screen (4-inch-diameter 304 stainless steel wire-wrap with a slot size of 0.010 inches), were lowered into the boring after the components were steam cleaned and measured. Five intervals were screened during the construction of MW-11 as shown in Table 5-23. Centralizers were bolted and clamped onto the casing above the bottom cap, within 1 to 2 feet of the top and bottom of each well screen, and at 40-foot intervals along the blank casing. The total depth of casing and screen in monitoring well MW-11 is 680 feet.

When the casing and screen string was lowered to the proper position within the borehole, the bentonite seals and sand packs were tremied into place. A grout pump was used to circulate drilling fluid out of the hole and to pump backfill materials into the boring. The backfill materials consist of sand, a bentonite sealing mixture of sand and bentonite, and volclay grout. Next to screened intervals and between bentonite seals, clean, kiln-dried RMC Lonestar #2/12 sand was used. Where a bentonite seal was required, a 1 to 1 mixture of pure bentonite granules (Enviroplug No. 16) and RMC Lonestar #2/12 sand was placed in the boring. The backfilling process was carefully monitored by frequent depth measurements with a weighted depth meter. Volclay grout was used to fill the remainder of the annulus from the top of uppermost seal to a depth of 23 feet below the ground surface. A bentonite-cement slurry grout was used to fill the remaining portion of the hole up to about 2 feet below the top of the well casing. After the grout cured, a locking monument cover and traffic box were concreted in place. Construction details for well EM-11 are shown on the boring log.

Initial development of the well began 24 hours after installation by lowering a 1.5-inch-diameter tremie pipe down to 200 feet off the bottom of the well and air lifting drilling mud out of the well using a Sol-Air 750 cubic feet per minute air compressor. Displaced drilling mud and water were collected in the rig's mud tanks and roll-off bins adjacent to the drill rig. The tremie pipe was then lowered to the bottom of the well and the procedure repeated.

Next, each screened section was swabbed from top to bottom using a double rubber-disc swab tool to flush fine materials from the sand pack. The well was then pumped and surged from top to bottom with a submersible pump. Development continued from the uppermost to the lowermost screened interval by using a tool comprised of two individual rubber packers inflated with compressed nitrogen. Each screen, in turn, was isolated and the interval was air-lifted.

After initial development, the multi-port (MP) casing system was installed. A typical MP casing system is illustrated in Figure 5-21. The MP system consists of various casing components including the following:

- Blank 1.5-inch-diameter Schedule 80 PVC casing.
- Regular PVC couplings that connect various casing-string components together.
- PVC measurement port couplings that allow pressure measurements and water samples to be collected.
- PVC pumping port couplings that allow well purging or hydraulic conductivity testing of the aquifer.
- Nitrile rubber inflatable packers that seal the annulus between monitoring or screened zones.

Each MP casing component that arrived on the site was pre-cleaned by the manufacturer with a non-phosphate detergent solution and packed in plastic bags for transport. Before the MP system was installed in well MW-11, the components were organized and partly assembled in accordance with a casing installation log. The casing installation log is used to accurately place the packers and measurement ports at the desired depths.

The MP casing string was assembled by lowering the casing segments into the 4-inch-diameter steel casing by hand and attaching each successive segment to the adjacent coupling one at a time. Each coupling was pressure tested before it was lowered into the hole to verify the integrity of the system during installation. To pressure test each coupling, a probe with two small packers was lowered into the casing so that the packers are located on each side of the coupling. The small packers were inflated and water was then injected under pressure into the casing opposite the coupling. If the coupling did not leak, it was lowered into the well.

62.0 mg/kg total xylenes. Soils contaminated with concentrations exceeding these levels are required to be discharged into a Class II landfill.

Excavation and removal of the contaminated soils started November 5, 1991, and continued through mid-January 1992. Approximately 16,130 tons of non-hazardous contaminated soil was transported to and disposed as Class III material at Laidlaw's Waste Systems Chiquita Canyon Facility in Valencia, California, and approximately 2,870 tons were transported to and disposed as Class II material at Laidlaw's Lokern Facility in Buttonwillow, California.

Confirmation sampling and analysis were continued at the locations shown in Figure 5-18, with some additional excavation being required, within the building's foundation area until TRPH concentrations were reported as non-detectable. It was decided that soil with minimal levels of TRPH (50 mg/kg or less) would be left in place and capped by the proposed parking lot's asphalt.

5.1.14 Ebasco Environmental (1992)

The occurrence of halogenated organics compounds in four City of Pasadena Municipal Water supply wells downgradient from JPL prompted investigations into the transport and fate of these compounds allegedly discharged at JPL. To evaluate the transport of organic compounds in groundwater from potential sources at JPL to the water supply wells, appropriate and applicable numerical models (computer codes) to simulate that transport and fate of constituents were required to be selected early in the CERCLA process.

To select an appropriate numerical model, major issues that must be considered include the complexity of site stratigraphy, the resolution (horizontal and vertical) required to assess contaminant plume transport, and the resolution required to evaluate remedial alternatives. Because of the variety of numerical models that could be used to study the JPL site, certain features of the models were used to group them into classes for evaluation. These features included the following criteria:

- Dimensionality (two or three dimensions)
- Finite difference or finite element
- Dynamic or steady state
- Saturated zone or confined flow
- Characteristics of the constituents transported
- Availability in the public domain
- Mass transport compatibility

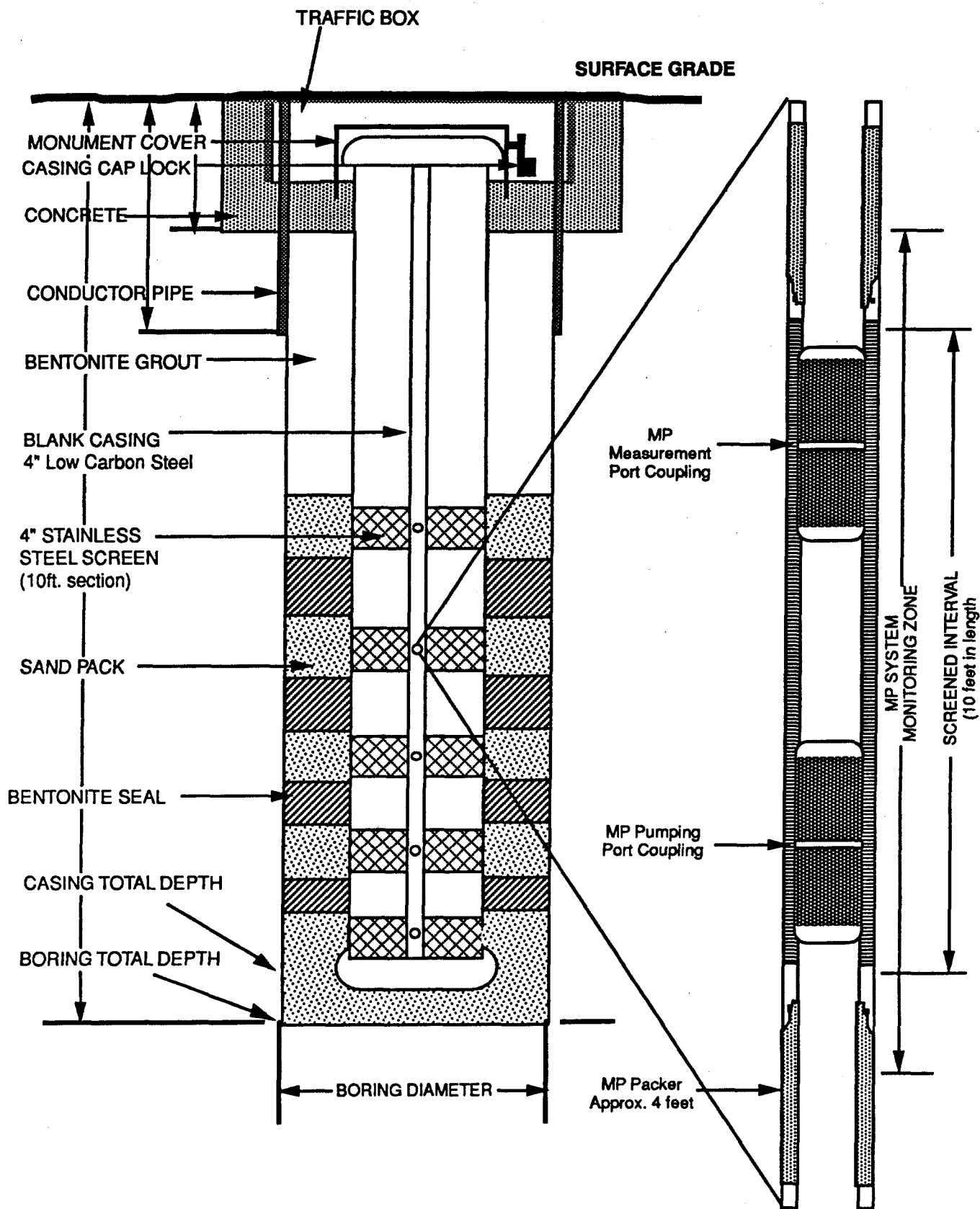


Figure 5 - 21

**Typical MP
Monitoring Well Installation**

Once the MP casing had been placed in each well, the nitrile rubber packers between screen intervals were inflated. The packers were inflated with water, one at a time beginning with the lowest packer, using a downhole tool designed for this purpose. After installation, several additional QA/QC checks were performed. These checks included an initial pressure profile to confirm the operation of the measurement ports and observation of head differences across the packers to confirm that the packers had properly sealed the annulus.

After installation of the MP casing system, each screened interval was developed further using a small inertial pumping system (flexible plastic tubing with check valve at bottom connected to a reciprocating motor at the surface). Prior to commencing development activities in the MP casing, the piezometric pressure at each screen interval was measured inside and outside the casing to ensure that formation water would flow into the casing when the pumping ports are opened for well development. The water level within the MP casing was adjusted as necessary to assure that the condition was maintained during development activities at each screen interval. Each screened interval was developed by opening the pumping-port valve at that screen and purging water from the screen interval using the pumping system selected. Pumping was occasionally discontinued to allow water within the discharge pipe to flow back into the well and lightly surge the formation. Development of each screen continued until the pH, temperature, electrical conductivity, and turbidity of the discharged water stabilized on the basis of measurements collected using field instruments that were calibrated at the beginning and end of each day following equipment manufacturer's specifications.

Deep Well Sampling

Sampling at MW-11 began after the Westbay sampling system had been installed and each screened interval had been developed. Samples from each screened interval were obtained using a Westbay Sampler Probe with a total capacity of approximately 1 liter. The sampler probe consists of a series of four 250-ml stainless steel collection tubes linked together with flexible, plastic-lined hoses. The uppermost collection tube is linked to an electrically activated valve-opening assembly. The entire apparatus was suspended and lowered down the MP casing on coaxial cable. Prior to sampling each screened interval, the sampler probe and collection tubes were disassembled and washed with phosphate-free detergent and rinsed with deionized water. The sampler probe was lowered to several feet below the measurement port coupling adjacent to the screen of interest and held stationary while an initial water-level measurement is taken.

The sampler probe was then raised and seated in the measurement port coupling of the screen being sampled. The measurement port coupling sample valve was opened remotely from the surface allowing the formation fluid to fill the sample collection tubes. The sample valve was then closed and a second water-level measurement was recorded.

At each screened interval, the pH, temperature, and conductivity of the groundwater were measured at the beginning and end of the sampling run. From each screen, several sample bottles were filled which required several sampling trips. At the surface, the water sample was emptied from the collection tubes through a valve at the lower end. Samples were collected in containers prepared and supplied by the analytical laboratory. All sampling, decontamination, and sample handling procedure used in reference to JPL Westbay multi-port wells (MW-3, MW-4, and MW-11), were identical to procedures used during previous sampling events as described in the JPL "Expanded Site Inspection Report" dated May 1990 (Ebasco, 1990a).

5.2.4 Results of Laboratory Analysis

All soil and groundwater samples were delivered to Montgomery Laboratories under chain-of-custody protocols for chemical analyses. To adequately screen the soil samples for various contaminants in a costly and timely manner, the type of analyses varied for each sample. Selection of analyses was weighted on the basis of the historic use of chemicals at JPL. Therefore, all samples were analyzed for volatile organics, the most probable contaminant; while, other samples were selected to be analyzed for less likely contaminants such as semi-volatile organics, TPH, cyanide, Title 22 metals and strontium. The analyses performed on each soil sample was arbitrarily determined upon the depth at which the sample was collected (see Table 5-22). Pending initial analytical results, many samples were archived. The archived samples were to be analyzed if and for contaminant(s) detected within the initial samples analyzed.

Analytical groundwater results for the four wells installed during the pre-RI field work are presented in Section 5.2.5 as a part of the ongoing periodic groundwater monitoring program. Groundwater samples from the four wells were collected during December 1992 and January 1993. The analytical results for the soil and groundwater samples are discussed in the following sections.

Soil Boring Samples

Following directives listed on Table 5-22, soil samples were submitted for organic and inorganic analyses. Organic analytes included volatile organics (EPA Method 8240), semi-volatile organics (EPA Method 8270), and TPH (EPA Method 418.1). Forty-six samples were analyzed for volatile organics, 10 samples for semi-volatile organics, and 11 samples for TPH.

Volatile organics were not detected in the 46 samples analyzed. Semi-volatile organics were detected in 2 of 10 samples analyzed. In samples SB1-6-60 (soil boring SB1, 60-foot sample) and SB12-3-30 (soil boring SB12, 30-foot sample) the organic compound was identified as

bis(2-ethylhexyl) phthalate - a common laboratory contaminant. Concentrations were 0.34 mg/kg and 0.6 mg/kg, respectively. The concentration of the extraneous peak was 0.2 mg/kg. TPH was detected in 1 of 11 soil samples analyzed. The sample, SB1-2-26 (soil boring SB1, 26-foot sample) had a TPH concentration of 59 mg/kg. Analytical results are presented in Table 5-24.

Inorganic analytes included cyanide (EPA Method 9010), Title 22 metals (except mercury) (EPA Method 6010/7000), mercury (EPA Method 245.1), strontium (EPA Method 6010/7000), percentage moisture versus total solids (EPA Method 160.3), nitrate (as N and NO_3) (EPA Method 300.0), and pH (EPA Method 150.1). Inorganic analytical results are reported in Table 5-25. Twelve samples were analyzed for cyanide, 15 samples for Title 22 metals and strontium, 10 samples for nitrate (as N and NO_3), 45 samples for percentage moisture versus total solids. Cyanide was detected in 1 of the 12 soil samples analyzed. For sample SB9-3-29.5-30 (soil boring SB9, 29.5- to 30-foot sample), the cyanide concentration was 1.06 mg/kg. Of the 15 samples analyzed for Title 22 metals and strontium, none exceeded the State of California action level for metals. Nitrate (as N) was not detected in 10 samples analyzed. Nitrate (as NO_3) was detected in 3 of 10 samples. Samples SB9-6-60 (soil boring SB9), 60-foot sample, SB12-3-30 (soil boring SB12, 30-foot sample), and SB19-3-30 (soil boring SB19), 30-foot sample, had nitrate (NO_3) concentrations of 1.6 mg/kg, 1.0 mg/kg, and 1.1 mg/kg, respectively. Percentage moisture versus total solids ranged between 2 percent in SB21-1-10 (soil boring SB21, 10-foot sample) to 13 percent in sample SB21-8-100 (soil boring SB21, 100-foot sample). Soil pH for the soil samples ranged between 4.7 in SB1-1-10 (soil boring SB1, 10-foot sample) to 8.1 in sample SB19-1-10DUP (soil boring SB19, 10-foot duplicate sample).

Water Samples

Monitoring wells MW-8, MW-10, and MW-11 were sampled as part of the ongoing periodic groundwater monitoring program discussed in Section 5.2.5. Monitoring well MW-9 could not be sampled since the access road to the well had been washed out along the Arroyo Seco. Water samples were collected in December 1992 and January 1993 and were analyzed for the corresponding parameters listed in Table 5-26. Analysis included volatile organics (EPA Method 524.2), alcohols and cyclohexanone (EPA Method 8240), Title 22 metals (EPA Method 6010/7000 series), cyanide (EPA Method 335.3), major anions (EPA Method 300 series), major cations (EPA Method 200 series), total organic carbon (EPA Method 415.1), total dissolved solids (EPA Method 160.1), specific conductance (EPA Method 120.1), and pH (EPA Method 150.1).

Analytical results for volatile organic compounds are presented in Table 5-27 along with other periodic sampling results. Volatile organic compounds detected included carbon tetrachloride, trichloroethene (TCE), tetrachloroethene (PCE), 1,1-dichloroethane (1,1,-DCA), total

TABLE 5-24

SUMMARY OF ORGANIC CHEMICAL ANALYSES PERFORMED ON SOIL BORING SAMPLES

1 of 3

Sample	Volatile Organics EPA 8240	Semi-Volatile Organics EPA 8270	Total Petroleum Hydrocarbons EPA 418.1
SB1-1-10	ND	ND	ND
SB1-2-26	ND	-	59
SB1-5-50	ND	-	-
SB1-6-60	ND	bis(2-ethylhexyl) phthalate 0.34	ND
SB1-7-69	ND	-	-
SB1-8-79	ND	-	-
SB1-9-89.5	ND	-	-
SB1-10-99.5	ND	-	-
SB9-1-10	ND	-	-
SB9-2-20	ND	-	-
SB9-3-29.5-30	ND	ND	ND
SB9-4-45	ND	-	-
SB9-6-60	ND	ND	ND
SB9-7-70	ND	-	-
SB9-8-80	ND	-	-
SB9-9-90	ND	-	-
SB9-10-100	ND	-	-
SB12-1-10	ND	-	-
SB12-2-20	ND	-	-
SB12-3-30	ND	bis(2-ethylhexyl) phthalate 0.6	ND

TABLE 5-24
SUMMARY OF ORGANIC CHEMICAL ANALYSES PERFORMED ON SOIL SAMPLES
(Continued)

2 of 3

Sample	Volatile Organics EPA 8240	Semi-Volatile Organics EPA 8270	Total Petroleum Hydrocarbons EPA 418.1
SB12-4-40	ND	-	-
SB12-4-40 Dup	ND	-	-
SB12-5-50	ND	-	-
SB12-6-60	ND	ND	ND
SB12-7-70	ND	-	-
SB12-8-80	ND	-	-
SB12-9-87	ND	-	ND
SB19-1-10	ND	-	-
SB19-1-10 Dup	ND	-	-
SB19-2-18	ND	-	-
SB19-2-18 Dup	ND	-	-
SB19-3-30	ND	(one) unknown scan #1815 0.2	ND
SB19-4-38	ND	-	-
SB19-5-50	ND	-	-
SB19-6-60	ND	ND	ND
SB19-7-70	ND	-	-
SB19-8-80	ND	-	-
SB19-9-90	ND	-	-
SB21-1-10	ND	-	-

TABLE 5-24
SUMMARY OF ORGANIC CHEMICAL ANALYSES PERFORMED ON SOIL SAMPLES
(Continued)

3 of 3

Sample	Volatile Organics EPA 8240	Semi-Volatile Organics EPA 8270	Total Petroleum Hydrocarbons EPA 418.1
SB21-2-20	ND	-	-
SB21-3-30	ND	ND	ND
SB21-4-60	ND	ND	ND
SB21-5-75	ND	-	-
SB21-6-80	ND	-	-
SB21-7-90	ND	-	-
SB21-8-100	ND	-	-

All results noted in mg/kg unless reported otherwise.

ND - Not Detected.

- Not Analyzed.

Sample Explanation:

SB1 - Soil boring.

1 - Sample number.

10 - Depth at which sample was collected.

TABLE 5-25
SUMMARY OF INORGANIC CHEMICAL ANALYSIS PERFORMED ON SOIL SAMPLES

Sample	Metals																					Percentage Moisture	Lab pH
	Ag	As	Ba	Be	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Sb	Se	Sr	Tl	V	Zn	CN	N	NO ₃		
TTLC	500	500	10000	75	100	8000	500	2500	20	3500	2000	1000	500	100	-	700	2400	5000	-	-	-	-	-
STLC	5	5	100	0.75	1	80	5	2.5	0.2	350	20	5	15	1	-	7	24	5	-	-	-	-	-
SB1-1-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4.7
SB1-2-26	ND	ND	43	ND	ND	ND	7.2	6.3	0.03	ND	ND	ND	ND	ND	17	ND	21	23	ND	ND	ND	4	7.1
SB1-5-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	7.4
SB1-6-60	ND	10	89	0.6	ND	ND	9.1	7.1	ND	ND	5.3	ND	ND	ND	17	ND	35	41	ND	ND	ND	13	7.6
SB1-7-69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	7.7
SB1-8-79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	7.8
SB1-9-89.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	7.9
SB1-10-99.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	7.9
SB9-1-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	6.8
SB9-2-20	ND	ND	87	ND	ND	ND	5.3	9.6	0.03	ND	4.2	ND	ND	ND	25	12	30	45	ND	-	-	7	7.3
SB9-3-29.5-30	ND	ND	120	0.5	ND	5.3	14	14	0.02	ND	7.4	ND	ND	ND	29	23	48	58	1.06	ND	ND	8	7.0
SB9-4-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7.3
SB9-6-60	ND	ND	120	0.7	ND	6.4	14	25	0.02	ND	9.5	ND	ND	ND	37	30	66	76	ND	ND	1.6	8	7.1
SB9-7-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	6.9
SB9-8-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	6.8
SB9-9-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	7.1
SB9-10-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	7.0
SB12-1-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7.3
SB12-2-20	ND	ND	74	ND	ND	ND	7.0	7.8	0.10	ND	ND	ND	ND	ND	33	ND	31	34	ND	-	-	7	7.1
SB12-3-30	ND	12	99	0.6	ND	ND	10	12	0.08	ND	6.3	ND	ND	ND	23	ND	48	53	ND	ND	1.0	13	7.2
SB12-4-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	7.3
SB12-4-40 Dup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SB12-5-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	6.8
SB12-6-60	ND	ND	82	ND	ND	ND	14	5.0	0.04	ND	ND	ND	ND	ND	23	ND	77	36	ND	ND	ND	8	7.2

TABLE 5-25

(Continued)

Sample	Metals																					Percentage Moisture	Lab pH
	Ag	As	Ba	Be	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Sb	Se	Sr	Tl	V	Zn	CN	N	NO ₃		
SB12-7-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	7.6
SB12-8-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	6.9
SB12-9-87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	7.3
SB19-1-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8.0
SB19-1-10 Dup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	8.1
SB19-2-18	ND	ND	95	ND	ND	ND	5.6	5.1	ND	ND	ND	ND	ND	ND	39	ND	30	29	ND	-	-	3	7.1
SB19-2-18 Dup	ND	ND	76	ND	ND	ND	3.1	4.3	ND	ND	ND	ND	ND	ND	16	ND	24	35	ND	-	-	3	6.9
SB19-3-30	ND	ND	40	ND	ND	ND	7.1	7.7	0.06	ND	ND	ND	ND	ND	31	ND	24	22	ND	ND	1.1	9	7.7
SB19-4-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7.6
SB19-5-50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	7.6
SB19-6-60	ND	ND	63	ND	ND	ND	5.1	11	0.10	ND	ND	ND	ND	ND	30	ND	36	38	ND	ND	ND	12	7.7
SB19-7-70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	7.5
SB19-8-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	7.6
SB19-9-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	7.8
SB21-1-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7.2
SB21-2-20	ND	ND	55	ND	ND	ND	6.4	6.2	0.04	ND	ND	ND	ND	ND	20	ND	31	27	ND	-	-	3	7.1
SB21-3-30	ND	10	70	0.5	ND	ND	12	16	0.08	ND	5.6	ND	ND	ND	32	ND	53	43	-	ND	ND	10	7.4
SB21-4-60	ND	ND	51	ND	ND	ND	10	8.3	ND	ND	ND	ND	ND	ND	13	ND	34	26	ND	ND	ND	13	7.6
SB21-5-75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	7.6
SB21-6-80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	7.7
SB21-7-90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	7.7
SB21-8-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	7.1

Values are reported in milligrams per kilogram (mg/kg) unless stated otherwise.

(1) Total solids reported as percentage total solids per unit volume.

ND - Not Detected

- Not Analyzed

TABLE 5-26

**SUMMARY OF ANALYSES PERFORMED ON GROUNDWATER SAMPLES COLLECTED
FROM JPL MONITORING WELLS
DECEMBER 1992 - JANUARY 1993**

Sample	Volatile Organic Compounds (SW 524.2)	Alcohols & Cyclohexanone by Aqueous Injection (SW 8240)	Title 22 Metals (Various Methods) ^a	Cyanide (EPA 335.3)	Major Anions/ Cations (Various Methods) ^b	Total Organic Carbon (EPA 415.1)	Total Dissolved Solids (EPA 160.1)	Specific Conductance (EPA 120.1)	pH (EPA 150.1)
MW-1	Not Sampled								
MW-3									
Screen 1 (Top)	X	X	X	X	X	X	X	X	X
Screen 2	X	X	X	X	X	X	X	X	X
Screen 2 Duplicate,(Dup 1)	X	X							
Screen 3	X	X	X	X	X	X	X	X	X
Screen 4	X	X	X	X	X	X	X	X	X
Screen 5 (Bottom)	X	X	X	X	X	X	X	X	X
MW-4									
Screen 1 (Top)	X	X	X	X	X	X	X	X	X
Screen 2	X	X	X	X	X	X	X	X	X
Screen 3	X	X	X	X	X	X	X	X	X
Screen 4	X	X	X	X	X	X	X	X	X
Screen 5 (Bottom)	X	X	X	X	X	X	X	X	X
MW-5	X	X	X	X	X	X	X	X	X
MW-6	X	X	X	X	X	X	X	X	X
MW-6 Duplicate,(Dup-3)	X	X							
MW-7	X	X	X	X	X	X	X	X	X
MW-7 Duplicate, (Dup-5)	X	X							
MW-8	X	X	X	X	X	X	X	X	X
MW-8 Duplicate, (Dup-4)	X	X							
MW-9	Not Sampled								
MW-10	X	X	X	X	X	X	X	X	X

TABLE 5-26
(Continued)

Sample	Volatile Organic Compounds (SW 524.2)	Alcohols & Cyclohexanone by Aqueous Injection (SW 8240)	Title 22 Metals (Various Methods) ^a	Cyanide (EPA 335.3)	Major Anions/ Cations (Various Methods) ^b	Total Organic Carbon (EPA 415.1)	Total Dissolved Solids (EPA 160.1)	Specific Conductance (EPA 120.1)	pH (EPA 150.1)
MW-11									
Screen 1 (Top)	X	X	X	X	X	X	X	X	X
Screen 2	X	X	X	X	X	X	X	X	X
Screen 3	X	X	X	X	X	X	X	X	X
Screen 3 Duplicate, (Dup-2)	X	X							
Screen 4	X	X	X	X	X	X	X	X	X
Screen 5 (Bottom)	X	X	X	X	X	X	X	X	X
EB-1 (MW-3)	X	X							
EB-2 (MW-4)	X	X							
EB-3 (MW-3)	X	X							
EB-4 (MW-11)	X	X							
EB-5 (MW-5,7,8)	X	X							
EB-6 (MW-6)	X	X							
TB-1 (MW-3)	X								
TB-2 (MW-4)	X								
TB-3 (MW-4)	X								
TB-4 (MW-3)	X								
TB-5 (MW-3)	X								
TB-6 (MW-11)	X								
TB-7 (MW-11)	X								
TB-10 (MW-5,6)	X								
TB-11 (MW-7,8,10)	X								

EB = Equipment Blank

TB = Trip Blank

a: Title 22 metals analyses: As - EPA 206.2; Hg - EPA 245.1; Pb - EPA 239.2; Se - EPA 270.2; Total Ag, Ba, Be, Cd, Co, Cr, Cu, Mo, Ni, Sb, Sr, Tl, V and Zn using ICP - SW 6010.

b: Major anions/cation analyses: Alkalinity - EPA 310.1; Cl - EPA 300; F - EPA 340.2; NO₃ as N - EPA 300; SO₄ - EPA 300; H₂PO₄ as P - EPA 365.4; Ca - EPA 215.1; total Fe (ICP) - SW 6010/EPA 200.7; K - EPA 258.1; Mg - EPA 242.1; Na - EPA 273.1.

TABLE 5-27

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
GROUNDWATER SAMPLES COLLECTED FROM JPL MONITORING WELLS
DECEMBER 1992 - JANUARY 1993**

(Concentrations in $\mu\text{g/l}$)

Sample	Carbon Tetra- chloride	TCE	PCE	1,1-DCE	1,1-DCA	1,2-DCA	Total Trihalo- methanes ^a	Toluene	Freon 113	Acetone	2-Methyl- 1-Propene
MW-3^a											
Screen 1 (Top)							7.8				
Screen 2	8.2	5.7					4.5				
Screen 2 Duplicate(Dup 1)	8.3	6.2					4.8				
Screen 3											
Screen 4											
Screen 5 (Bottom)											
MW-4^a											
Screen 1 (Top)											
Screen 2		1.7									
Screen 3											
Screen 4											
Screen 5 (Bottom)											
MW-5^b											
MW-6^c			0.5								
MW-6 ^c Duplicate, (Dup-3)			0.5								
MW-7 ^b	120 ^a	40 ^a	4.8	4.0		0.9	17 ^a		9.0		
MW-7 ^b Duplicate, (Dup-5)	120 ^b	32 ^b	4.6	4.6		0.9	15 ^b		6.6		
MW-8 ^b		0.8					0.8				
MW-8 ^b Duplicate, (Dup-4)	0.5	0.9					0.9				
MW-10 ^b		15 ⁱ	0.6		0.7		2.0	0.7	2.0		

TABLE 5-27
(Continued)

(Concentrations in $\mu\text{g/l}$)

Sample	Carbon Tetra- chloride	TCE	PCE	1,1-DCE	1,1-DCA	1,2-DCA	Total Trihalo- methanes ^e	Toluene	Freon 113	Acetone	2-Methyl- 1-Propene
MW-11 ^a											
Screen 1 (Top)	17						2.3				
Screen 2	8.1						4.7				
Screen 3	2.8						3.3				
Screen 3 Duplicate, (Dup-2)	3.6						3.6				
Screen 4							2.9				
Screen 5 (Bottom)							1.2				
EB-1 ^a (MW-3)							8.3				1.3
EB-2 ^a (MW-4)							7.3				1.2
EB-3 ^a (MW-3)							1.3			16	
EB-4 ^a (MW-11)							3.0			10	
EB-5 ^b (EMW-5,7,8)							0.7				
EB-6 ^c (MW-6)							0.7				
Practical Quantitation Limit	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	10	0 ^d
Regulatory Threshold	0.5 ^k	5 ^k	5 ^k	6 ^k	5 ^k	0.5 ^k	100 ^k	40 ^l	1,200 ^k	unregulated	unregulated

a: Samples collected with Westbay sampling probe.

b: Samples collected with disposable teflon bailer.

c: Samples collected with stainless steel bailer.

d: Derived from California Administrative Code, Title 22 Maximum Contaminant Level for drinking water or USEPA Drinking Water Standards and Health Advisories Table.

e: Total Trihalomethanes including chloroform, bromoform, dibromochloromethane and dichlorobromomethane.

f: Action level; non-enforceable health based guidance number.

g: Dilution factor of 20, practical quantitation limit of 10 $\mu\text{g/l}$.

h: Dilution factor of 25, practical quantitation limit of 12.5 $\mu\text{g/l}$.

i: Dilution factor of 2, practical quantitation limit of 1 $\mu\text{g/l}$.

j: Concentration arrived at through comparison with similar compounds. No detection limits available.

k: California DOHS primary MCL.

l: USEPA proposed secondary MCL.

trihalomethanes, toluene, and Freon 113. The various volatile organic compounds were not detected in all monitoring wells or in all screens within the deep multi-port well. Carbon tetrachloride concentrations met or exceeded California State Maximum Contaminant Levels (MCL) in water samples for monitoring wells MW-8 and MW-11 (Screens 1, 2, 3). TCE concentrations exceeded the MCL in water samples for monitoring wells MW-10 and MW-11 (Screens 1 and 2). PCE, 1,1-DCE, 1,1-DCA, total trihalomethanes, toluene, and Freon 113 concentrations did not exceed the MCL. Acetone and 2-methyl-1-propene were not detected in the three wells. In addition, alcohols and cyclohexanone were not detected. Analytical results for Title 22 metals, strontium, cyanide, and total organic carbon are presented in Table 5-28. All concentrations were below MCLs. A summary of the water chemistry results is presented in Table 5-29. Tables 5-28 and 5-29 are presented in Section 5.2.5 as part of the ongoing quarterly groundwater monitoring program.

As part of the water sampling program, equipment and trip blanks (as designated in Table 5-26) were collected as part of the field QA/QC procedures and the analytical results are presented in Table 5-27.

Duplicate samples are used as an independent means of evaluating the precision of the laboratory analyses. Five duplicate groundwater samples were collected from selected wells and labeled sequentially (DUP-1, DUP-2, DUP-3, DUP-4, and DUP-5). The duplicate samples were submitted for analysis along with the other samples. The duplicate samples were analyzed for volatile organic compounds (EPA 524.2). The comparison of analytical results between the water samples and the duplicate samples were within 20 percent except for the following:

- The concentration of Freon 113 in the duplicate sample collected at well MW-7 (DUP-5) was 2.4 $\mu\text{g/l}$ lower than that of sample MW-7 (9.0 $\mu\text{g/l}$).
- Carbon tetrachloride was found at its detection limit (0.5 $\mu\text{g/l}$) in the duplicate sample collected at MW-8 (DUP-4) but not in sample MW-8.
- The concentration of carbon tetrachloride measured in the duplicate sample collected from the third screen of multi-port well MW-11 was 3.6 $\mu\text{g/l}$ and that measured in the original sample was 2.8 $\mu\text{g/l}$.

Equipment blanks are used to determine if any contaminants are introduced into the samples by the sampling equipment. Equipment blanks were prepared by pouring distilled water through the sampling device and collecting the rinsate in sample bottles appropriate for volatile organic compound analyses. A total of six equipment blanks were collected and submitted for analysis. Four equipment blanks were obtained from the sampling probe used to collect groundwater samples from the multi-port wells and two equipment blanks were obtained from bailers used to collect groundwater samples from the shallow wells. Low concentrations of trihalomethanes

were detected in all of the equipment blanks collected from the groundwater sampling devices (EB-1, EB-2, EB-3, EB-4, EB-5, and EB-6). Acetone and 2-methyl-1-propene, were also detected in EB-3 and EB-4, and in EB-1 and EB-2, respectively. The occurrence and concentration of trihalomethanes detected in the equipment blanks do not correlate with that detected in the groundwater samples. Acetone and 2-methyl-1-propene were not detected in any groundwater samples.

Trip blanks are used to determine if any contaminants are introduced into the samples during transportation. Trip blanks are sample containers filled with reagent water prepared in advance by the laboratory. A total of nine trip blanks were submitted, one for each day of groundwater sampling. The trip blanks were analyzed for volatile organic compounds using EPA 524.2. No organic compounds were detected.

Much of the work was completed prior to the NPL listing in October 1992. As noted in the previous section, a portion of the work outlined in the draft RI work plan was completed. This included the limited soil borings, the soil gas program, and the installation of four additional groundwater wells.

The information provided by completing this work has been exceptionally valuable to the development of the current RI work plan. Based on the initial pre-RI work, the current work plan calls for additional soil gas survey work, additional soil borings, and additional well installations.

5.2.5 Periodic Groundwater Monitoring Program

The overall goal of the ongoing periodic groundwater sampling and analysis program is to contribute to the successful completion of the Remedial Investigation (RI) and to provide the data needed to select a remedial alternative in the Feasibility Study (FS). To achieve this goal, the program must effectively assess the nature and extent of contaminants in the groundwater related to the JPL facility and provide information on hydrogeologic parameters involved with contaminant transport.

Periodic groundwater monitoring at JPL was initiated in March 1990 when five monitoring wells were installed as part of the Expanded Site Inspection of JPL. The analytical results for that initial sampling event were reported in the Expanded Site Inspection Report (Ebasco, 1990a). At the time of the initial sampling event, the existing monitoring well network consisted of seven wells. With the completion of this pre-RI phase of work, the monitoring well network was increased to 11 wells. Including the initial round of sampling, eight groundwater monitoring

events have been completed. A sampling event was performed in March 1990, June 1990, December 1990, June 1991, October 1991, April 1992, September 1992, and January 1993.

Groundwater parameters measured in the field include temperature, specific conductivity, and pH. These parameters are measured while each well is being purged. Once the parameters have stabilized water samples are collected. This is done to ensure that a sufficient amount of groundwater has been purged prior to sampling such that analytical results are truly representative of the aquifer and not conditions that exist within the well casing and borehole.

During the course of the periodic groundwater monitoring program, laboratory analyses have included volatile organic compounds (EPA Method 624; EPA Method 524.2), semi-volatile organic compounds (EPA Method 625), total petroleum hydrocarbons (EPA Method 418.1), organochlorine pesticides and polychlorinated biphenols (PCBs) (EPA Method 6010/7000), major anions (EPA Method 300 series), major cations (EPA 200 series), total organic carbon (TOC) (EPA Method 415.1), total dissolved solids (TDS) (EPA Method 160.1), and radioactivity (gross alpha and gross beta) (EPA Method 9310). Analyses performed on water samples collected from each well during the eighth sampling event is presented in Table 5-26, and the analytical results for that sampling event are presented in Tables 5-27, 5-28, and 5-29.

A summary of the volatile organic compounds detected in groundwater samples collected from the JPL monitoring wells that existed since periodic monitoring was initiated are presented in Tables 5-30, 5-31, and 5-32. A review of the results indicate the following trends for volatile organics in monitoring wells at JPL:

- Carbon tetrachloride is detected at more or less consistent levels over time in well MW-7 and in the second screened interval of multi-port well MW-3.
- Trichloroethene (TCE) is detected in wells MW-5 and MW-7 and in the second screened intervals of multi-port wells MW-3 and MW-4. TCE has been consistently detected in well MW-7 but the concentrations appear to fluctuate over time with no clear relationship. The concentration of TCE detected in well MW-5 and in the second screened interval of multi-port well MW-3 appear to be decreasing over time. Low concentrations of TCE are consistently found in the second screened interval of multi-port well MW-4.
- Low concentrations of total trihalomethanes are consistently detected in the second screened interval of multi-port well MW-3.
- Low concentrations of ethylbenzene and styrene are consistently detected in the third screen interval of multi-port well MW-3.

TABLE 5-28

**SUMMARY OF TITLE 22 METALS, STRONTIUM, CYANIDE AND TOTAL ORGANIC CARBON (TOC) DETECTED IN
GROUNDWATER SAMPLES COLLECTED FROM JPL MONITORING WELLS
DECEMBER 1992 - JANUARY 1993
(Concentrations in mg/l)**

Well Name	Ag	As	Ba	Be	Cd	Co	Cr	Cu	Hg (µg/l)	Mo	Ni	Pb	Sb	Se	Sr	Tl	V	Zn	TOC	Cyanide
MW-3																				
Screen 1								0.047							0.29			0.044	1.0	0.006
Screen 2			0.060					0.023							0.40			0.035	0.9	0.008
Screen 3								0.010							0.23			0.033	0.5	0.007
Screen 4		0.006	0.076					0.052							0.23			0.360		
Screen 5		0.016						0.019							0.07			0.490	0.6	
MW-4																				
Screen 1								0.043							0.28			0.240	0.9	0.009
Screen 2			0.090												0.63			0.240	0.9	0.012
Screen 3		0.006	0.054												0.31			0.220	0.6	0.019
Screen 4								0.020							0.28			0.210		
Screen 5								0.013							0.31			0.240		0.021
MW-5								0.015				0.007			0.23	0.10		0.070	2.3	
MW-6			0.084				0.240	0.018				0.009			0.64			0.180	2.3	
MW-7			0.052				0.011	0.012							0.37			0.048	0.7	
MW-8			0.150				0.025	0.110	0.20			0.030			0.34			0.280	3.0	
MW-10			0.280				0.026	0.066	0.30			0.017			0.94			0.290	2.2	
MW-11																				
Screen 1		0.011						0.017							0.41			0.040	1.1	
Screen 2		0.013						0.064							0.35			0.150	1.1	
Screen 3			0.050					0.025							0.37			0.140	0.7	
Screen 4								0.042							0.33			0.074	0.9	
Screen 5								0.029		0.050					0.20			0.100	0.8	
Practical Quantitation																				
Limit	0.01	0.005	0.05	0.005	0.005	0.05	0.01	0.01	0.2	0.05	0.04	0.002	0.05	0.00	0.01	0.1	0.05	0.02	0.5	0.005
Regulatory																				
Threshold ^a :	0.05 ^b	0.05 ^c	1 ^c	0.004 ^d	0.05 ^c	UR	0.05 ^c	1 ^c	2 ^b	UR	0.1 ^d	0.05 ^c	0.006 ^d	0.01 ^b	UR	0.002 ^d	UR	5 ^c	UR	0.2 ^d

Metal Concentrations represent unfiltered samples.

UR: Unregulated

a: Derived from California Administrative Code Title 22 Maximum Contaminant Levels for Drinking Water or USEPA Drinking Water Standards and Health Advisories table.

b: California DOHS Secondary MCL.

c: California DOHS Primary MCL.

d: USEPA Primary MCL.

e: USEPA Secondary MCL.

TABLE 5-29

**SUMMARY OF WATER CHEMISTRY RESULTS FOR GROUNDWATER
SAMPLES COLLECTED FROM JPL MONITORING WELLS
DECEMBER 1992 - JANUARY 1993**

(Concentrations in mg/l unless otherwise noted)

Well Name	F	Cl	Alkalinity CO ₃ +HCO ₃	NO ₃	P	SO ₄	Na	Mg	K	Ca	Fe	Measured TDS	pH ¹	Measured EC (Corrected) ²
MW-1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-3-1	0.67	11	150	5.3	0.00	26	16	14	2.6	38	0.20	210	7.46	363
MW-3-2	0.66	16	185	10.1	0.00	41	18	19	3	51	0.14	290	7.5	483
MW-3-3	0.87	16	145	0.0	0.00	10	41	7.5	3.2	17	0.38	200	8.7	329
MW-3-4	0.75	11	130	0.0	0.00	14	46	6.3	2.5	8.3	0.18	170	9.06	295
MW-3-5	3.10	9.7	140	0.0	0.00	10	69	0	1.2	4.3	0.00	190	9.7	320
MW-4-1	0.41	12	135	2.7	0.00	24	19	12	2.7	34	0.00	200	7.19	351
MW-4-2	0.41	71.5	150	21.7	0.00	71.9	29	28	2.9	76	0.77	390	7.16	755
MW-4-3	0.54	12	160	15.5	0.00	5.9	32	12	2	32	0.00	240	8.06	400
MW-4-4	0.55	14	160	19.0	0.00	8.3	37	11	2.1	29	1.00	220	8.01	384
MW-4-5	0.48	8.5	135	0.0	0.00	12.2	38	9.1	2.4	21	0.20	170	8.34	331
MW-5	0.24	7.9	115	3.1	0.00	21	12	10	2.5	29	4.70	180	9.88	284
MW-6	0.25	77	180	32.1	0.14	90	27	29	2.5	79	21.00	470	6.92	775
MW-7	0.73	24	160	27.7	0.09	45	20	19	2.7	51	3.30	300	7.32	559
MW-8	0.63	8.7	145	6.6	0.47	27	16	14	3	40	15.00	210	7.25	354
MW-9	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-10	0.28	84	245	74.8	0.33	130	29	42	3.8	110	16.00	610	6.94	1016
MW-11-1	0.55	26	235	5.3	1.80	68	69	16	4.3	46	3.00	380	8.02	664
MW-11-2	0.75	22	235	0.9	6.20	65	67	14	3.9	41	0.42	370	8.07	646
MW-11-3	0.67	16	195	0.0	1.10	54	50	11	2.9	37	0.74	300	8.28	518
MW-11-4	0.68	15	195	0.0	3.50	40	55	9.6	3.1	32	0.85	280	8.33	513
MW-11-5	0.62	13	160	0.0	4.10	28	63	3.7	2.3	15	1.20	240	8.35	417

1-pH values are field results not corrected for temperature and reported in units of pH (1 through 14).

2-Measured EC values are field results corrected for temperature and cell constant and are reported in uS/cm.

TABLE 5-30

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
GROUNDWATER SAMPLES COLLECTED FROM JPL MONITORING WELL MW-3**
(Concentrations in µg/l)

Parameter	Sampling Date:	Concentration (Practical Quantitation Limit)								Regulatory Threshold ^b
		3-90	6-90	12-90	6-91	11-91	4-92	9-92	12/92	
WELL MW-3										
SCREEN 1 (Top)										
Total Trihalomethanes ^a		7(5)	44(5)	13(5)	-(0.5)	18(0.5)	-(0.5)	-(0.5)	7.8(0.5)	100
SCREEN 2										
Carbon Tetrachloride		-(5)	-(5)	-(5)	5.3(0.5)	2(0.5)	7.6(0.5)	2.3(0.5)	8.2(0.5)	0.5
Trichloroethene (TCE)		-(5)	-(5)	13(5)	19.(0.5)	20(0.5)	11(0.5)	2.1(0.5)	5.7(0.5)	5
Tetrachloroethene (PCE)		-(5)	-(5)	-(5)	1.2(0.5)	1.3(0.5)	-(0.5)	-(0.5)	-(0.5)	5
Total Trihalomethanes ^a		6(5)	6(5)	6(5)	4(0.5)	6(0.5)	10(0.5)	3.7(0.5)	4.5(0.5)	100
SCREEN 3										
Ethylbenzene		-(5)	-(5)	-(5)	0.6(0.5)	0.5(0.5)	0.6(0.5)	0.8(0.5)	-(0.5)	680
Styrene		-(5)	-(5)	-(5)	0.9(0.5)	0.8(0.5)	0.7(0.5)	0.8(0.5)	-(0.5)	unregulated
SCREEN 4										
No Detects										
SCREEN 5 (Bottom)										
Carbon Disulfide		-(5)	-(5)	-(5)	NA	NA	-(1.25)	0.6(0.5)	-(0.5)	unregulated
Styrene		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.5(0.5)	-(0.5)	unregulated

-: Not Detected.

NA: Not Analyed.

a: Includes chloroform, bromoform, dibromochloromethane, and dichlorobromomethane.

b: California Administration Code, Title 22 Maximum Contaminant Levels for Drinking Water.

TABLE 5-31

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
GROUNDWATER SAMPLES COLLECTED FROM JPL MONITORING WELL MW-4**

(Concentrations in µg/l)

Parameter	Sampling Date:	Concentration (Practical Quantitation Limit)								Regulatory Threshold ^b
		3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92	
WELL MW-4										
SCREEN 1 (Top)										
Trichloroethene (TCE)		-(5)	-(5)	8(5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	5
Total Trihalomethanes ^a		-(5)	-(5)	-(5)	-(0.5)	0.7(0.5)	-(0.5)	-(0.5)	-(0.5)	100
1,1,1-Trichloroethane		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	5.2(0.5)	-(0.5)	-(0.5)	200
SCREEN 2										
Tetrachloroethene (TCE)		-(5)	-(5)	-(5)	1.7(0.5)	0.9(0.5)	1.5(0.5)	1.7(0.5)	1.7(0.5)	5
Total Trihalomethanes ^a		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.5(0.5)	-(0.5)	100
SCREEN 3										
Trichloroethene (TCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	2.3(0.5)	-(0.5)	-(0.5)	5
Tetrachloroethene (PCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	2.6(0.5)	-(0.5)	-(0.5)	5
1,1,1-Trichloroethane		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	3.4(0.5)	-(0.5)	-(0.5)	200
Toluene		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	0.5(0.5)	-(0.5)	-(0.5)	100
SCREEN 4										
No Detects										
SCREEN 5 (Bottom)										
Acetone		-(10)	-(10)	-(10)	NA	NA	-(10)	25(10)	-(10)	100 ^c

—: Not Detected.

NA: Not Analyzed.

a: Includes chloroform, bromoform, dibromochloromethane, and dichlorobromomethane.

b: California Administration Code, Title 22 Maximum Contaminant Levels for Drinking Water.

c: Non-enforceable health based guidance number.

TABLE 5-32

**SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN
GROUNDWATER SAMPLES COLLECTED FROM MW-5, MW-6, AND MW-7**

(Concentrations in µg/l)

Parameter	Sampling Date:	Concentration (Practical Quantitation Limit)								Regulatory Threshold ^b
		3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93	
WELL MW-1										
Trichloroethene (TCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.7(0.5)*	Not Sampled	5
Tetrachloroethene (PCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.6(0.5)*		5
Total Xylenes		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.6(0.5)*		1750
WELL MW-5										
Carbon Tetrachloride		-(5)	-(5)	-(5)	0.7(0.5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	0.5
Trichloroethene (TCE)		13(5)	-(5)	86(5)	26(0.5)	16(0.5)	4.5(0.5)	1.0(0.5)*	-(0.5)	5
Tetrachloroethene (PCE)		-(5)	-(5)	-(5)	-(0.5)	0.6(0.5)	3.8(0.5)	0.8(0.5)*	-(0.5)	5
1,1-Dichloroethane		-(5)	-(5)	-(5)	-(0.5)	-0.8(0.5)	-(0.5)	-(0.5)	-(0.5)	5
Total Trihalomethanes ^a		-(5)	-(5)	7(5)	2.4(0.5)	2.3(0.5)	-(0.5)	-(0.5)	-(0.5)	100
Toluene		-(5)	6(5)	-(5)	-(0.5)	-(0.5)	-0.9(0.5)	-(0.5)	-(0.5)	100
cis-1,2-Dichlorethene		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	5.4(0.5)	-(0.5)	-(0.5)	6
Total Xylenes		-(5)	11(5)	-(5)	-(0.5)	-(0.5)	1.3(0.5)	0.9(0.5)*	-(0.5)	1750
WELL MW-6										
Trichloroethene (TCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.8(0.5)*	-(0.5)	5
Tetrachloroethene (PCE)		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.9(0.5)*	0.5(0.5)	5
Total Trihalomethanes ^a		30(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	100
Toluene		-(5)	6(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	-(0.5)	100
Total Xylenes		-(5)	-(5)	-(5)	-(0.5)	-(0.5)	-(0.5)	0.8(0.5)*	-(0.5)	1750
WELL MW-7										
Carbon Tetrachloride		200(5)	200(5)	130(5)	190(0.5)	31(0.5)	260(25)	230(12.5)	120(10)	0.5
Trichloroethene (TCE)		22(5)	27(5)	5(5)	7.5(0.5)	2(0.5)	30(25)	39(12.5)	40(10)	5
Tetrachloroethene (PCE)		15(5)	9(5)	28(5)	15(0.5)	5.5(0.5)	-(25)	-(12.5)	4.8(0.5)	5
1,1-Dichloroethene		8(5)	6(5)	14(5)	6.7(0.5)	3(0.5)	-(25)	-(12.5)	4.0(0.5)	6
1,2-Dichloroethane		-(5)	-(5)	-(5)	-(5)	-(5)	-(25)	-(12.5)	9.0(0.5)	5
Total Trihalomethanes ^a		23(5)	19(5)	15(5)	14(5)	5.4(0.5)	-(25)	19(12.5)	17(10)	100
Toluene		-(5)	5(5)	-(5)	-(0.5)	-(0.5)	-(25)	-(12.5)	-(0.5)	100
Freon 113		NA	NA	NA	NA	NA	NA	NA	9.0(0.5)	1200

*: Equipment blank results indicate these VOC values may have resulted from trace concentrations remaining in the purge pump.

-: Not Detected.

a: Includes chloroform, bromoform, dibromochloromethane, and dichlorobromomethane.

NA: Not Analyzed

b: California Administration Code, Title 22 Maximum Contaminant Levels for Drinking Water.

6.0 JPL REMEDIAL INVESTIGATION OBJECTIVES

Under the CERCLA RI/FS process the RI serves as the mechanism for collecting data to characterize site conditions, determine the nature of the waste, and assess risk to human health and the environment and to conduct the Feasibility Studies. In addition, under the RI, treatability testing may occur to evaluate the potential performance and cost of the treatment technologies that are being considered.

As previously described, JPL has been divided into three operable units. Each unit will have a specific approach for the RI. The specific RI approach is summarized below for OU-1, the on-site groundwater characterization; OU-2, the on-site contaminant source characterization; and OU-3, the off-site groundwater characterization. Three separate RI reports will be presented; however, the RI report (and ROD) for OU-3 will include data and evaluations made in the OU-1 and OU-2 reports. The approach for the RI for OU-1, OU-2, and OU-3 is outlined in Sections 6.1.2, 6.2.2, and 6.3.2, respectively.

However, this does not exclude the fact that work done under the RI phase for one operable unit may contribute to the progress and completion of the objectives of another operable unit. The goals of the RI, based on previous investigations conducted at JPL and vicinity, have been outlined during the recent scoping meetings with NASA, EPA, and CalEPA. Some of these goals have been filled by research and field investigations performed by Ebasco. One of the primary objectives of the RI will be to identify any additional goals, collect and evaluate the data to fill these goals and develop a comprehensive understanding of the hydrogeologic and contaminant nature for all three operable units.

Presented in this section is an evaluation and identification of the data-needs required for completing the JPL Remedial Investigation. It is a general preview of activities that will be conducted. A description of activities planned for the Feasibility Study is provided in Section 8.0 of this Work Plan.

The objectives of the Remedial Investigation/Feasibility Study include the following:

- Characterization of potential contaminant content in the soil at JPL due to past waste handling activities.
- Characterization of the nature and extent of contaminants in the groundwater beneath and surrounding JPL.
- Performance of a risk assessment based on the characterization of site conditions, and existing and potential contaminant migration pathways.

- Evaluation of available remedial technologies, and, if necessary, the recommendation of potential remedial alternatives for the site.

To fulfill these objectives, the RI will include activities designed to evaluate existing data, and to collect and analyze new data in support of the FS.

The RI/FS at the JPL will be undertaken according to the EPA's Office of Soil Waste and Emergency Response (OSWER) Directive 9355.0-7B titled "Data Quality Objectives for Remedial Response Activities: Development Process." Under EPA procedures, data quality objectives in support of the RI/FS are developed through a three-stage process.

Stage 1 of the DQO process defines the types of decisions that will be made regarding site remediation through identifying data users, evaluating available data, developing a conceptual model, and specifying objectives for the project. The conceptual model, based on available information, describes suspected sources, contaminant pathways, and potential receptors to facilitate decisions which must be made and deficiencies in the existing information.

Stage 2 involves specifying the data necessary to meet the objectives set in Stage 1. Sampling approaches and the analytical options for the site are selected in Stage 2.

In Stage 3 the data-collection program is designed so that data of acceptable quality and quantity will be obtained.

The development of Data Quality Objectives (DQOs) governing proposed sampling activities at JPL constitutes an integral part of the RI/FS program. The OSWER Directive 9355.0-7B states that "Data Quality Objectives are qualitative and quantitative statements specified to ensure that data of known and appropriate quality are obtained in support of remedial response activities and agency decisions."

Data Quality Objectives are developed through an iterative process designed to establish the level and extent of sampling and analysis required to produce data adequate for the evaluation of remedial alternatives. DQO Stage 1 occurs during the initial RI/FS scoping period. This process has been underway through scoping meetings involving the EPA, DTSC, RWQCB, NASA-JPL, and consultants. Initial scoping meetings were held on December 8-9, 1992, January 14-15, 1993, and March 9, 1993. Minutes of these scoping meetings will be contained in the Information Repository. Stages 2 and 3 are follow on activities which will be repeated during the iterative DQO process to achieve the RI/FS goals.

Specific Data Quality Objectives can be defined according to the following EPA levels of sophistication:

- **Level I - Field Screening**: Characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support.
- **Level II - Field Analysis**: Characterized by the use of portable analytical instruments which can be used on-site, or in mobile laboratories stationed near a site.
- **Level III** - This level is used primarily in support of engineering studies using standard EPA approved procedures without the EPA's Contract Laboratory Program requirements for documentation.
- **Level IV** - This level is characterized by rigorous QA/QC protocols and documentation and provides qualitative and quantitative analytical data.
- **Level V** - Non-standard methods. Analyses which may require method modification and/or development.

EPA Level IV QA/QC documentation will be delivered for all JPL RI data for constituents of interest. During the initial field investigation phase for all OU's, and 10 percent of all samples collected subsequently, the level IV data will be validated as a check on laboratory performance. Implementation and specific EPA sophistication levels are described in the individual operable units FSAP and under site characterization for each unit below.

In addition, the following quality assurance objectives for analytical data, will be identified according to the following criteria:

- **Precision**: Precision represents the reproducibility of measurements under a given set of conditions.
- **Accuracy**: Accuracy is a measure of the bias in a sample measurement system.
- **Representativeness**: Representativeness is the degree to which the sample data accurately and precisely represent an environmental condition.
- **Completeness**: Completeness is the percent of measurements made which are judged to be valid.
- **Comparability**: Comparability expresses the confidence with which one data set can be compared with another.

Objectives for the existing soil and groundwater information base for JPL that have been identified are discussed in the RI subsections that follow. The need to achieve a given objective and the degree to which it is achieved will be prioritized to most efficiently meet the objectives of the RI/FS and to fulfill pertinent regulatory obligations.

Ultimately, the RI/FS will provide the information necessary to establish potential risks to human health and the environment and to select the most appropriate remedial alternative for the site should it be warranted. The RI format for each operable unit, consisting of data quality objectives, site characterization, baseline risk assessment, and a description of sampling strategy, is presented below.

6.1 OPERABLE UNIT 1 RI FOR ON-SITE GROUNDWATER

Operable Unit 1 encompasses the groundwater beneath JPL over to the Arroyo Seco area east of JPL. OU-1, as a groundwater component of the impacted subsurface environment, represents the operable unit with the greatest potential of being a conduit for wastes migrating beyond the JPL region. The RI for OU-1 will focus primarily on refining present understanding of the constituents of interest (Table 6-2, Section 6.1.2) in the groundwater, the groundwater-flow dynamics and the risks to human health and environment. The RI, as part of the RI/FS process, will progress according to the EPA DQO process. The following sections on data quality objectives, site characterization, risk assessment, and sampling strategies include detailed descriptions of the procedures and strategy for completing the RI phase. The data quality objectives section generally covers DQO Stages 1 and 2 and briefly summarizes data needs for the RI. The characterization section represents Stage 3 of the DQO process for the RI.

6.1.1 Data Quality Objectives for OU-1

Data developed for OU-1 during the RI will be used for risk assessment, site characterization, screening and evaluation of remedial alternatives and remedial design. The primary data requirements for the on-site groundwater investigation relate to water-quality issues and understanding of the groundwater-flow regime. The goal of the RI phase of the RI/FS will be to further identify the nature of the constituents of interest in groundwater and the horizontal and vertical extent of these compounds. Also, through the use of water-quality, water-level, and other related hydrologic and hydrogeologic data, a more comprehensive understanding of the dynamic nature of the OU-1 groundwater will be attained.

Historic water-quality and water-level data, collected for the local production wells, indicate a change in the water quality with pumpage and time. Thus, it will be important to monitor both water levels and water quality routinely throughout the RI from existing and new monitoring wells to determine if changes in water quality occur with time or with pumping of nearby municipal water production wells. Additionally, water samples will be collected from the proposed monitoring wells to further assess the occurrence of constituents of interest in the groundwater. Analysis of chemical data from these water samples should aid in determining the

extent of constituents of interest and may also aid in detecting any shift in the constituents of interest due to intermittent pumping of the nearby municipal production wells.

As stated above, EPA Level IV data validation procedures will be required to assess the constituents of interest in the groundwater. All of the data on constituents of interest obtained during the initial RI sampling event, and 10 percent of the data subsequently, collected during the RI, will be validated as a check on laboratory performance. Data on general minerals (major anions/cations) and total dissolved solids (TDS), not considered constituents of interest, will be generated and reported with as EPA Level III data. The sampling, data handling and laboratory sample control procedures are described in more detail in the OU-1 FSAP and JPL RI/FS QAPP.

Collection and evaluation of these water-quality and quantity data will be controlled by the RI/FS DQO process, where realization of the goals of the OU-1 RI will be an iterative process. Data acquired during drilling and construction of new wells and data from monitoring programs will be reassessed throughout the program to ensure that the overall and specific objectives and data gaps are filled. Using the iterative DQO process will allow NASA to create an accurate and complete picture of OU-1 so that remedial action can commence in a timely manner.

Water-level data from routine measurements in existing and proposed monitoring wells is required to determine the direction of groundwater flow, the effects of pumping from the nearby municipal production wells, and the effects of artificial and natural recharge. The water-level data will be used to construct a series of water-level maps depicting the change in water-table configuration created by the pumping wells and precipitation events with time. A computer model will be used to predict the long-term effects of pumpage. Understanding the changes to the groundwater configuration over time will aid determination of the location of hydrologic boundaries, including groundwater divides, and their impact to contaminant transport.

Prior to development of this plan, NASA initiated an evaluation of the available relevant groundwater flow and solute transport model codes that would aid in the RI/FS and RD effort. This evaluation (Ebasco, 1992) resulted in the selection of the MODFLOW code and the companion solute transport code RAND3D. It should, however, be noted that the level of complexity of the hydrogeologic system will serve as the basis for the final decision on the extent of groundwater flow and solute transport modeling conducted during the RI/FS. MODFLOW and RAND3D have been selected for possible use on this project for flow studies, well capture zone evaluations and optimization simulations. Computer modeling will aid in the evaluation of the potential impacts of DGDMUP and the remedial alternatives being assessed. The DGDMUP has the potential to dramatically impact the configuration of the groundwater

table that surrounds the JPL. As the DGDMUP takes shape it may be necessary to model these potential impacts prior to selection of the final remedial alternatives and will be needed during the RD phase.

Hydraulic-conductivity data will be used to estimate the rate and volume of groundwater flow and, therefore, contaminant-migration rates at the JPL site. When hydraulic-conductivity and water-level data are input to a numerical model, the model may be used to simulate groundwater flow and the effects of pumping. Data to calculate hydraulic conductivity values can be obtained from measurements in the deep multi-port wells, from production-well data, and/or from aquifer test data. Hydraulic conductivities may vary by more than two or three orders of magnitude in non-stratified sediments owing to the heterogeneity of the materials.

To fully understand the dynamics of the groundwater-flow system and the amount of groundwater which would have to be managed in a remedial-action system, the geometry of the aquifer will need to be further defined and a subregional water budget calculated. Knowledge of aquifer geometry will be refined by the proposed drilling and boring programs for OU-1 and OU-3. A water budget will be developed that includes the effects of recharge calculated from precipitation less evapotranspiration and runoff losses, and from groundwater sources and sinks such as the spreading grounds and pumping centers.

In addition to these requirements, the historic pumping rates and any water-level measurements from the local production wells will be reviewed to aid in determining the potential aquifer drawdown due to long-term pumping. Future plans and schedules for pumping of the nearby municipal wells will be reviewed and incorporated into the verification of a groundwater flow model. Both historic and potential recharge from the Arroyo Seco Canyon and Arroyo Seco spreading grounds will have to be estimated and incorporated into the model.

Data requirements for the groundwater investigation include the following:

- Water-quality samples from existing monitoring wells, analyzed by a state-certified laboratory according to EPA guidelines;
- Water-quality samples collected after installation of proposed monitoring wells;
- Historic water-level and quality data from nearby production wells;
- Water-level data from existing and proposed monitoring wells, measured to the nearest 0.01 ft;
- Aquifer coefficients of hydraulic conductivity and storativity from deep multi-port wells, from previously conducted tests of production wells, aquifer tests in the shallow wells, and from a long term aquifer pump test, if additional data is required;
- Historic and future pumping rates from local production wells;

- Historic climatological data on precipitation;
- Sub-regional streamflow and runoff data;
- Solubility coefficients of primary chemical constituents in OU-1 aquifer material; and
- Physical soil properties of aquifer material.

6.1.2 On-Site Groundwater Characterization

Presented in this section is a summary of the proposed Remedial Investigation (RI) activities for the on-site groundwater characterization at JPL. Discussions addressing the proposed field activities, sample analyses, data evaluation, and the RI report format are presented here. Complete details concerning the investigation are included in the FSAP prepared for OU-1.

The on-site groundwater component of the RI focuses on determining where contaminants may occur, the vertical and horizontal extent of contaminants, and the concentrations of contaminants beneath and downgradient of potential source areas at JPL. Five new well locations are proposed based on information from previous investigations, including soil and groundwater, site hydrogeology, and history of waste-disposal practices. The locations of proposed and existing monitoring wells along with known seepage-pit locations and the location of the trace of the JPL Thrust Fault are presented in Figure 6-1. The proposed well locations have been selected to enhance understanding of areas already under study and to allow collection of data in areas where specific information is lacking. If contaminant source areas are identified north of the JPL Thrust Fault, their impact on the groundwater will be evaluated, with monitoring wells located north of the fault, if necessary, during the latter stages of the RI.

The rationale for selecting each proposed monitoring well location was primarily based on water-level and VOC data previously collected from the existing wells. Previous groundwater monitoring efforts primarily focused on VOCs in the groundwater. A summary of water-table elevations and the volatile organic compounds detected in the past in existing wells MW-1, MW-3, MW-4, MW-5, MW-6, and MW-7 are illustrated on Figures 6-2 through 6-7, respectively, and a summary of water-table elevations and volatile organic compounds detected in new wells MW-8, MW-10, and MW-11 (installed between December 1992 and January 1993) are summarized in Table 6-1. During the RI, all constituents of interest (Table 6-2) will be evaluated in the groundwater. Below is a summary of the rationale for the location of each new well.

- **Rationale for Well MW-12**

Well MW-12, a proposed 4-inch-diameter, deep multi-port monitoring well (see OU-1 FSAP), will be located southeast of Building 302, at the southeast boundary of JPL (Figure 6-1). It will be approximately 900 feet to the southeast (regionally downgradient) of existing shallow well MW-7, the well exhibiting the highest level

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SITE PLAN - FACILITY LOCATIONS

- EXPLANATION**
- Shallow Monitoring Well
 - ▲ Deep MP Monitoring Well
 - ⊙ Proposed Shallow Monitoring Well
 - ⊙ Proposed Deep MP Monitoring Well
 - 37 Seepage Pit or Dry Well Location
 - G Soil Gas Sampling Location
 - WP-3 Suspected Waste Disposal Area
 - Trace of JPL Thrust Fault (Agbabian Associated, 1977)

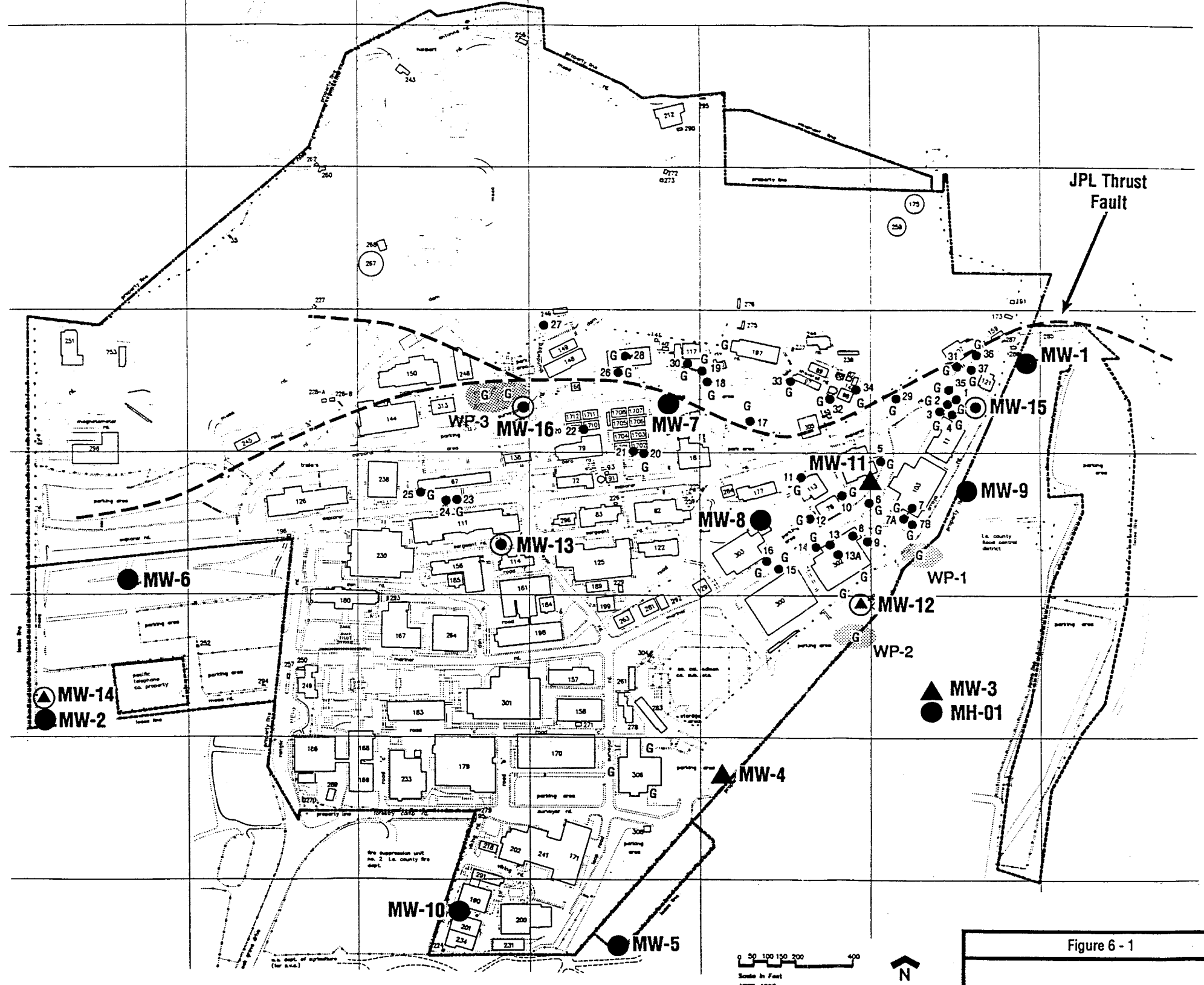
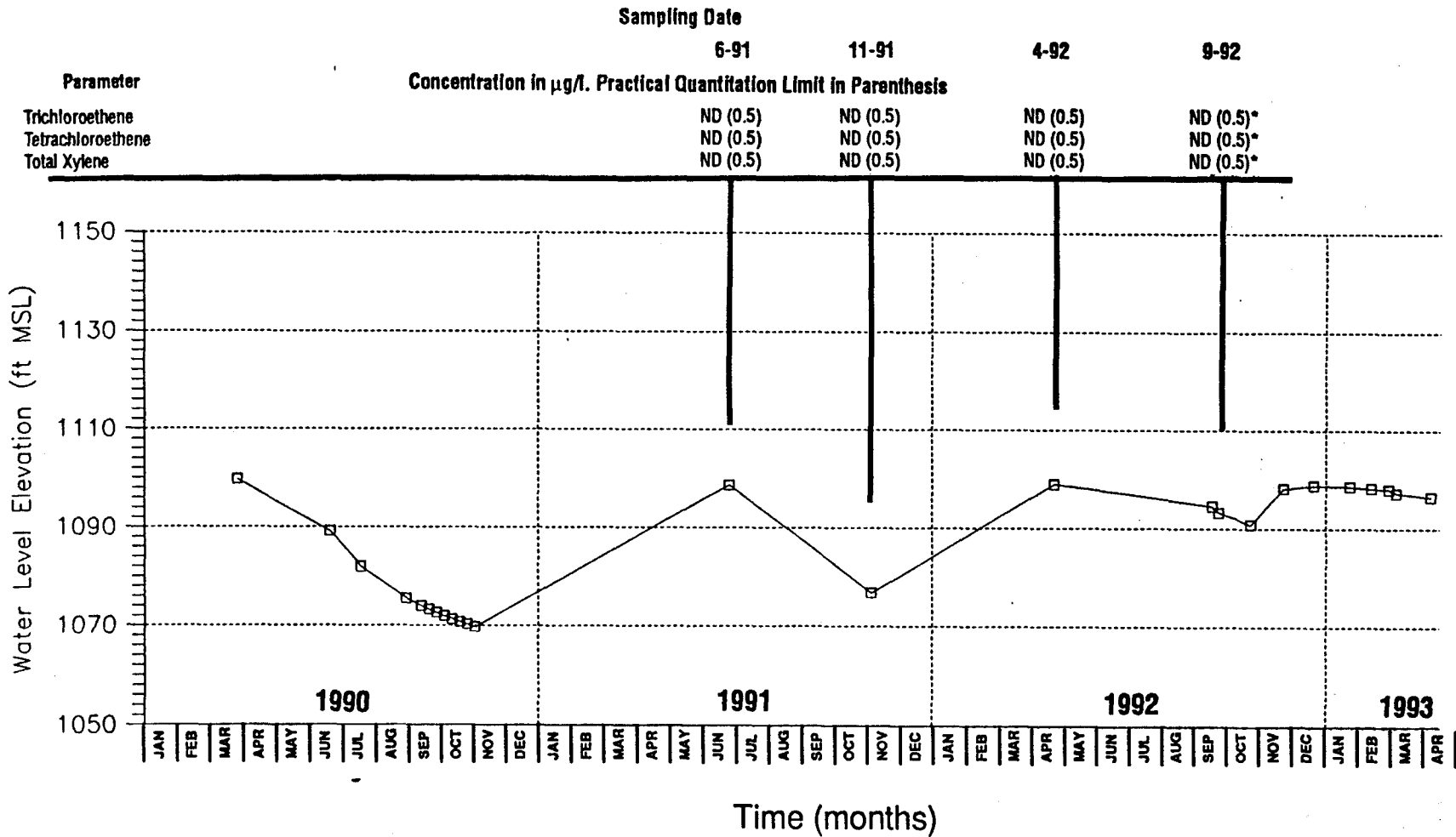


Figure 6 - 1

Existing and Proposed
Monitoring Well Location Map

Well MW-1



ND: Not Detected

*: TCE (0.7 $\mu\text{g/l}$), PCE (0.6 $\mu\text{g/l}$), and Xylenes (0.6 $\mu\text{g/l}$) were detected but were also detected in the equipment blank.

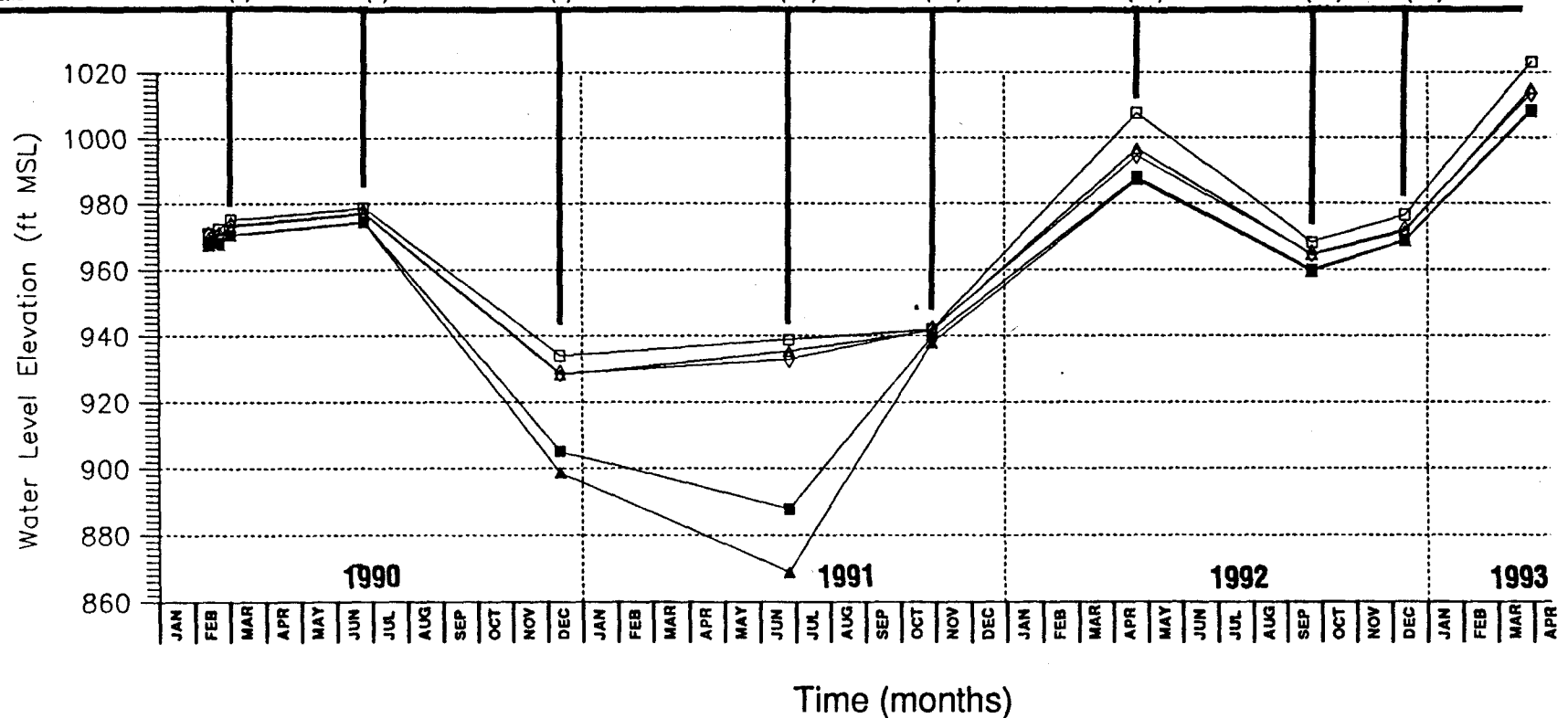
Figure 6 - 2

**Concentrations of VOCs
Detected in Groundwater and
Water Level Elevations in
Monitoring Well MW-1**

Well MW-3

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92
Concentration in µg/l. Practical Quantitation Limit in Parenthesis								
Screen 1 Total Trihalomethanes ^a	7(5)	44(5)	13(5)	ND(0.5)	18(0.5)	ND (0.5)	ND (0.5)	7.8(0.5)
Screen 2 Carbon Tetrachloride	ND (5)	ND (5)	ND (5)	5.3(0.5)	2(0.5)	7.6(0.5)	7.6(0.5)	8.2(0.5)
Trichloroethene	ND (5)	ND (5)	13(5)	19(0.5)	20(0.5)	11(0.5)	11(0.5)	5.7(0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	1.2(0.5)	1.3(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Trihalomethanes	6(5)	6(5)	6(5)	4(0.5)	6(0.5)	10(0.5)	10(0.5)	4.4(0.5)
Screen 3 Ethylbenzene	ND (5)	ND (5)	ND (5)	0.6(0.5)	0.5(0.5)	0.6(0.5)	0.6(0.5)	ND (0.5)
Styrene	ND (5)	ND (5)	ND (5)	0.9(0.5)	0.8(0.5)	0.7(0.5)	0.7(0.5)	ND (0.5)
Screen 4 No Detects	-	-	-	-	-	-	-	-
Screen 5 Carbon Disulfide	ND (5)	ND (5)	ND (5)	NA	NA	ND (1.25)	ND (1.25)	ND (0.5)
Styrene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)



ND: Not Detected

NA: Not Analyzed

a: Includes Chloroform, Bromoform, Dibromochloromethane, and Dichlorobromomethane

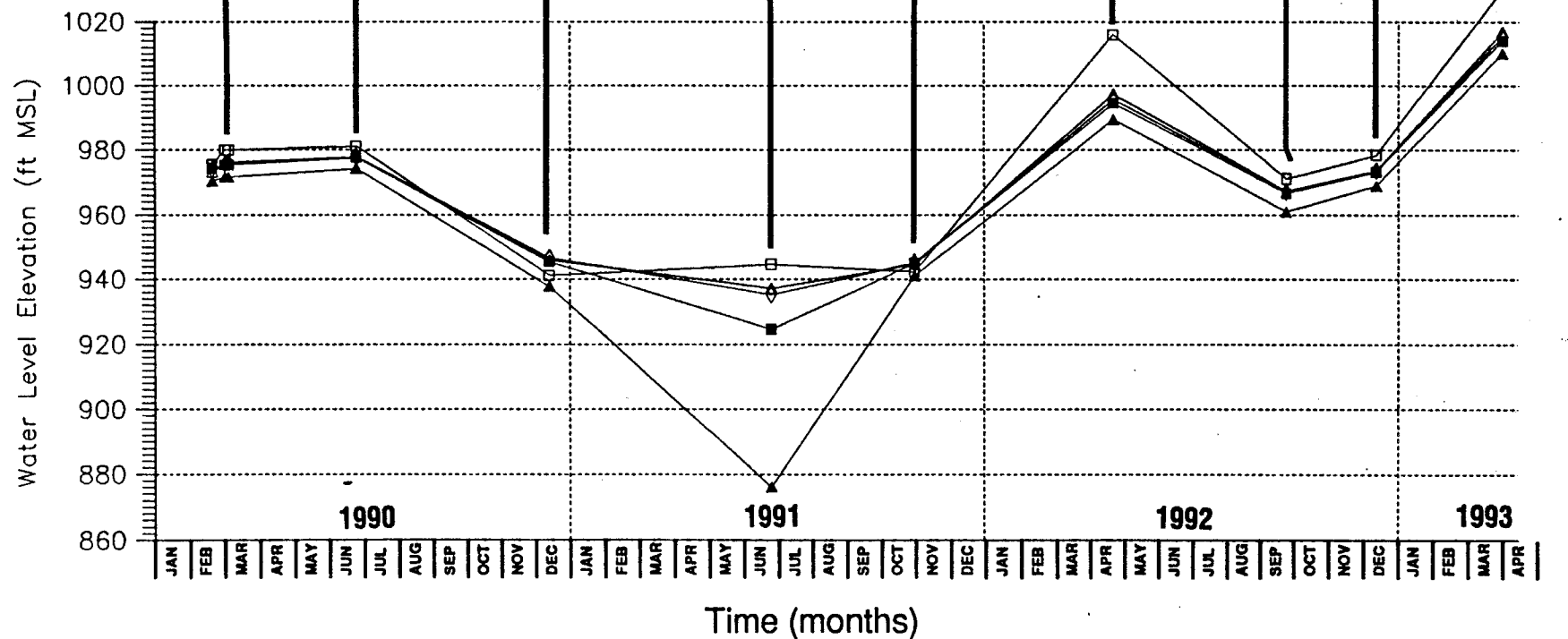
Figure 6 - 3

Concentrations of VOCs
Detected in Groundwater and
Water Level Elevations in
Monitoring Well MW-3

Well MW-4

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92
Concentration in µg/l. Practical Quantitation Limit in Parenthesis								
Screen 1 Trichloroethene	ND (5)	ND (5)	8(5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Trihalomethanes ^a	ND (5)	ND (5)	ND (5)	ND (0.5)	0.7(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
1,1,1-Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	5.2(0.5)	ND (0.5)	ND (0.5)
Screen 2 Trichloroethene	ND (5)	ND (5)	ND (5)	1.7(0.5)	0.9(0.5)	1.5(0.5)	1.7(0.5)	1.7(0.5)
Total Trihalomethanes	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	0.5(0.5)	ND (0.5)
Screen 3 Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	2.3(0.5)	ND (0.5)	ND (0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	2.6(0.5)	ND (0.5)	ND (0.5)
1,1,1-Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	3.4(0.5)	ND (0.5)	ND (0.5)
Toluene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	0.5(0.5)	ND (0.5)	ND (0.5)
Screen 4 No Detects								
Screen 5 Acetone	- (10)	- (10)	- (10)	NA	NA	- (10)	25(10)	- (10)



ND: Not Detected

NA: Not Analyzed

^a Includes Chloroform, Bromoform, Dibromochloromethane, and Dichlorobromomethane

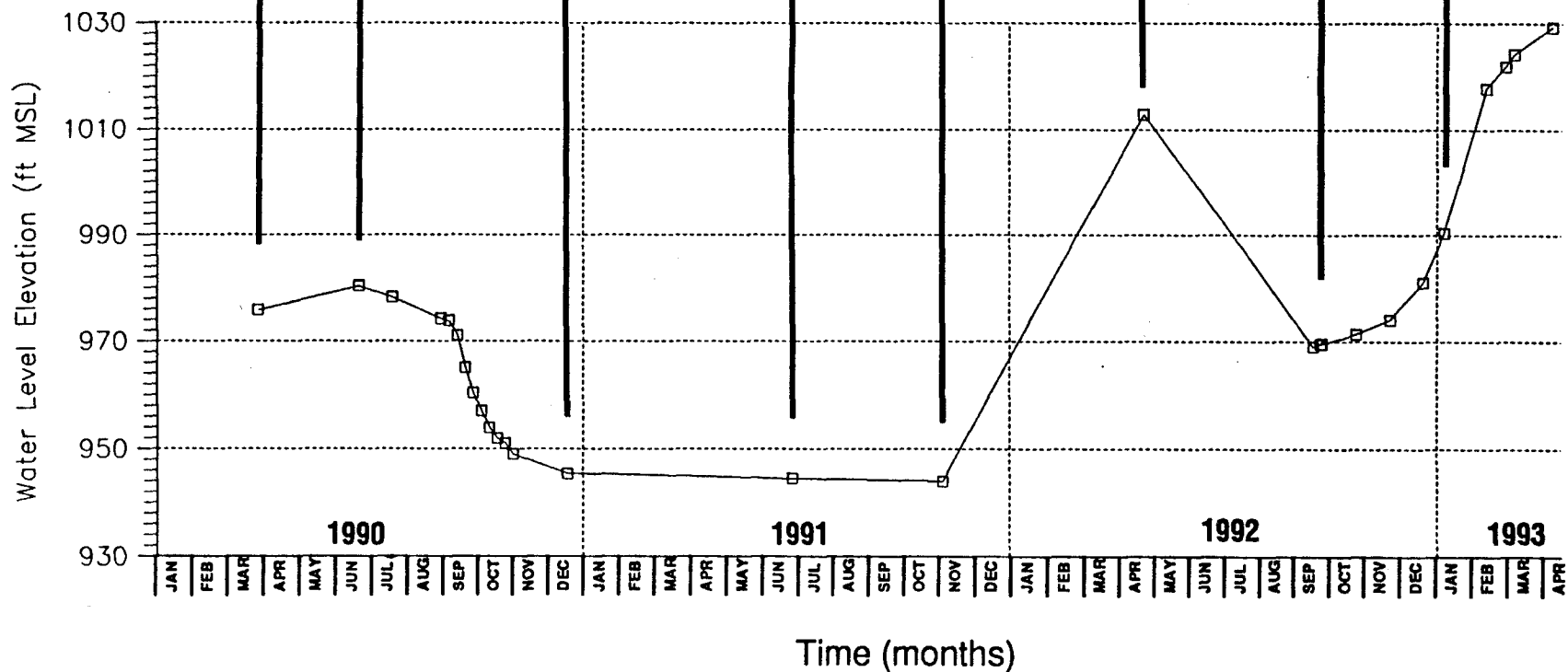
Figure 6 - 4

Concentrations of VOCs
Detected in Groundwater and
Water Level Elevations in
Monitoring Well MW-4

Well MW-5

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
Concentration in $\mu\text{g/l}$. Practical Quantitation Limit in Parenthesis								
Carbon Tetrachloride	ND (5)	ND (5)	ND (5)	0.7(0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Trichloroethene	13(5)	ND (5)	86(5)	26(0.5)	16(0.5)	4.5(0.5)	1.0(0.5)*	ND (0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	0.6(0.5)	3.8(0.5)	0.8(0.5)*	ND (0.5)
1,1-Dichloroethane	ND (5)	ND (5)	ND (5)	ND (0.5)	0.8(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Trihalomethanes	ND (5)	ND (5)	7(5)	2.4(0.5)	2.3(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	ND (5)	6(5)	ND (5)	ND (0.5)	ND (0.5)	0.9(0.5)	ND (0.5)	ND (0.5)
cis-1,2-Dichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	5.4(0.5)	ND (0.5)	ND (0.5)
Total Xylenes	ND (5)	11(5)	ND (5)	ND (0.5)	ND (0.5)	1.3(0.5)	0.9(0.5)*	ND (0.5)



ND: Not Detected

*: Equipment Blank Results Indicate These VOC Values May Have Resulted From Trace Concentrations Remaining In The Purge Pump

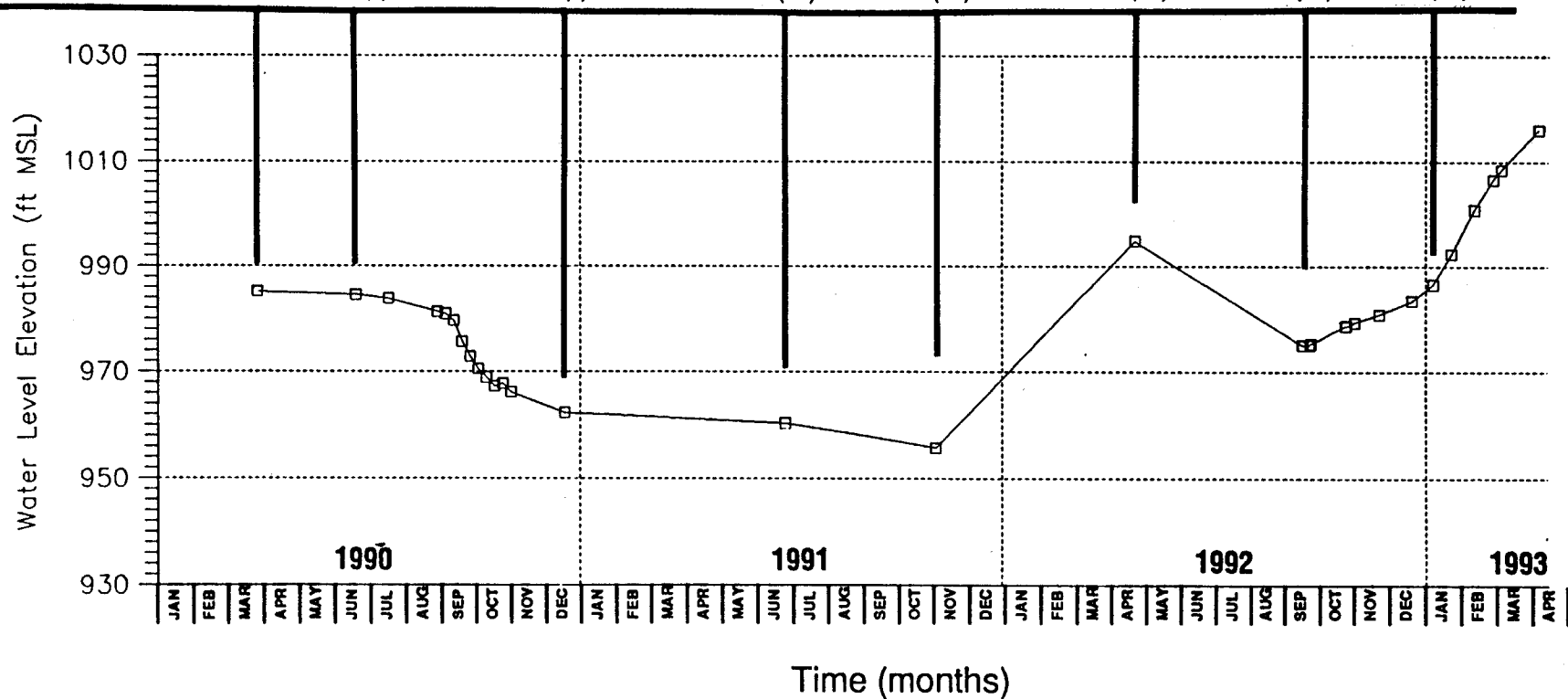
Figure 6 - 5

Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-5

Well MW-6

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
Concentration in $\mu\text{g/l}$. Practical Quantitation Limit in Parenthesis								
Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	ND (0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	0.5(0.5)
Total Trihalomethanes	30(5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	ND (5)	6(5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Xylenes	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	ND (0.5)



ND: Not Detected

* TCE (0.8 $\mu\text{g/l}$), PCE (0.9 $\mu\text{g/l}$), and Xylenes (0.8 $\mu\text{g/l}$) were detected but were also detected in the equipment blank.

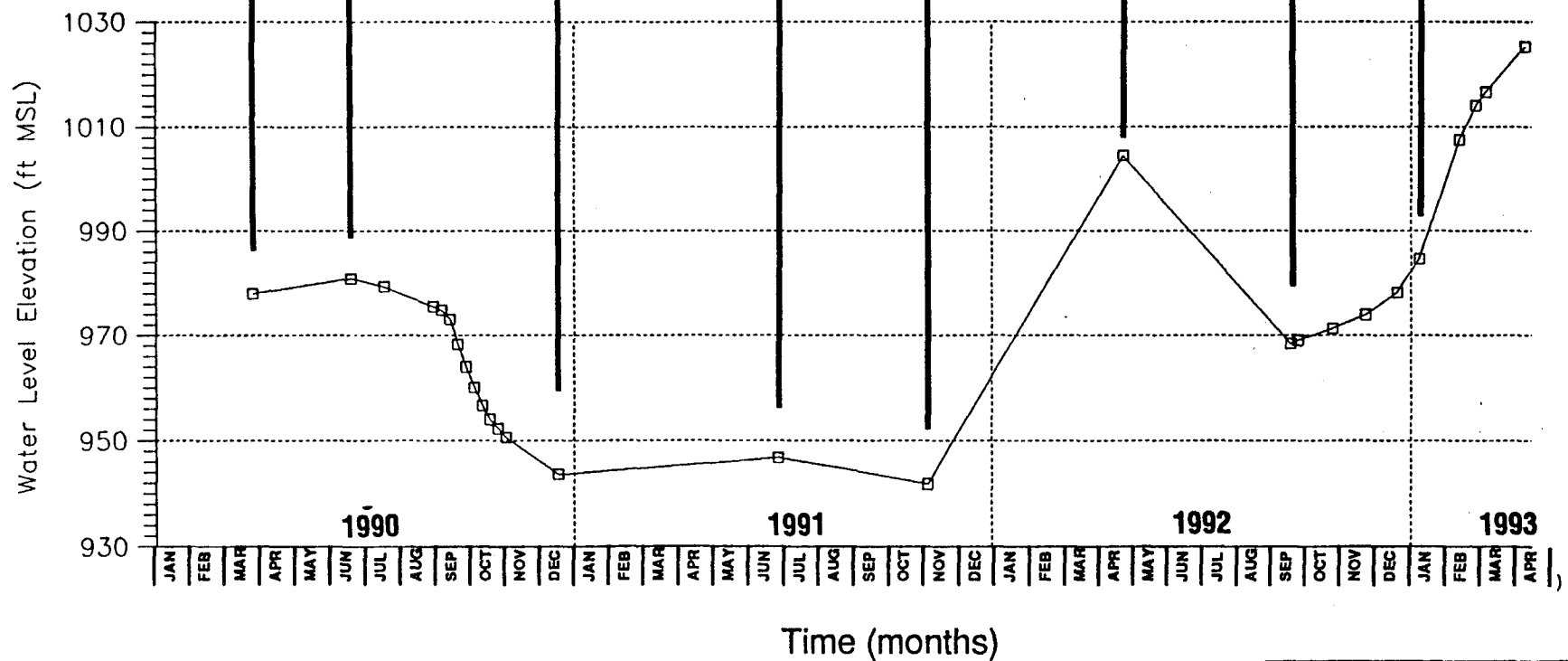
Figure 6 - 6

**Concentrations of VOCs
Detected in Groundwater and
Water Level Elevations in
Monitoring Well MW-6**

Well MW-7

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
Concentration in $\mu\text{g/L}$. Practical Quantitation Limit in Parenthesis								
Carbon Tetrachloride	200(5)	200(5)	130(5)	190(0.5)	31(0.5)	260(0.5)	230(12.5)	120(10)
Trichloroethene	22(5)	27(5)	5(5)	7.5(0.5)	2(0.5)	30(0.5)	39(12.5)	40(10)
Tetrachloroethene	15(5)	9(5)	28(5)	15(0.5)	5.5(0.5)	ND (25)	ND (12.5)	4.8(0.5)
1,1-Dichloroethane	8(5)	6(5)	14(5)	6.7(0.5)	3(0.5)	ND (25)	ND (12.5)	4.0(0.5)
1,2-Dichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (25)	ND (12.5)	9.0(0.5)
Total Trihalomethanes	23(5)	19(5)	15(5)	14(0.5)	5.4(0.5)	ND (25)	19(12.5)	17(10)
Toluene	ND (5)	5(5)	ND (5)	ND (0.5)	ND (0.5)	ND (25)	ND (12.5)	ND (0.5)
Freon 113	NA	NA	ND (5)	ND (0.5)	ND (0.5)	NA	NA	9.0(0.5)



ND: Not Detected
NA: Not Analyzed

Figure 6 - 7
Concentrations of VOCs
Detected in Groundwater and
Water Level Elevations in
Monitoring Well MW-7

TABLE 6-1**SUMMARY OF WATER LEVEL ELEVATIONS AND VOCs
DETECTED IN WELLS MW-8, MW-10 AND MW-11**

Parameters	Concentration (Practical Concentration Limit) January 1993 µg/l	Groundwater Elevation (feet above mean sea level)
MW-8		
Trichloroethene	0.8 (0.5)	988.33
Total Trihalomethanes*	0.8 (0.5)	
MW-9		
Not sampled (access road washed out)		N/A
MW-10		
Trichloroethene	15.0 (1.0)	985.07
Tetrachloroethene	0.6 (0.5)	
1-1,Dichloroethane	0.7 (0.5)	
Toluene	2.0 (0.5)	
Freon 113	0.7 (0.5)	
Total Trihalomethanes	2.0 (0.5)	
MW-11		
SCREEN 1		
Carbon Tetrachloride	17.0 (0.5)	1041.9
Total Trihalomethanes	2.3 (0.5)	
SCREEN 2		
Carbon Tetrachloride	8.1 (0.5)	1022.8
Total Trihalomethanes	4.7 (0.5)	
SCREEN 3		
Carbon Tetrachloride	2.8 (0.5)	1015.8
Total Trihalomethanes	3.3 (0.5)	
SCREEN 4		
Total Trihalomethanes	2.9 (0.5)	1018.6
SCREEN 5		
Total Trihalomethanes	1.2 (0.5)	1005.5

*Includes chloroform, bromoform, dibromochloromethane, and dichlorobromomethane.

TABLE 6-2

**SUMMARY OF PROPOSED ANALYSES FOR GROUNDWATER
SAMPLES, SOIL SAMPLES, AND SAMPLES OF SOIL CUTTINGS,
JET PROPULSION LABORATORY**

Parameter	Proposed Analytical Method ¹	Groundwater Samples	Duplicate Groundwater Samples	Groundwater Equipment Blanks	Groundwater Trip Blanks	Soil Samples	Composited Samples of Soil Cuttings
CONSTITUENTS OF INTEREST							
Volatile Organic Compounds	EPA 524.2	X	X	X	X		
Volatile Organic Compounds	EPA 8240					X ⁶	X
Semi-Volatile Organic Compounds	EPA 8270	X	X	X		X	X
Title 26 Metals with Hexavalent Chromium (Plus Strontium)	EPA 6010 ²	X	X	X		X	X (w/o hexavalent chromium)
Cyanide	EPA 335.3	X	X	X		X	X
Total Petroleum Hydrocarbons	EPA 418.1	X ³	X ³	X ³		X	X
Radioactivity Gross Alpha Gross Beta	EPA 9310	X ⁴	X ⁴	X ⁴			
Nitrate	EPA 300.0					X	
NOT CONSTITUENTS OF INTEREST⁵							
Major Cations	EPA 200 Series	X	X				
Major Anions	EPA 300 Series	X	X				
Total Dissolved Solids	EPA 160.1	X	X				
Total Solids	EPA 160.3					X	

1: Equivalent methods may be used.

2: EPA Method 6010 will be used in all water analyses except for arsenic (EPA 206.2); Lead (239.2), Antimony (EPA 204.2), Selenium (EPA 270.2), Thallium (EPA 279.2) and Mercury (EPA 245.1). EPA 6010 detection limits for these metals exceed their respective drinking water MCLs. For Hexavalent Chromium EPA 218.5 will be used.

3: Existing well MW-4 only.

4: Proposed well MW-13 only.

5: Constituents added to RI to help evaluate flow patterns, groundwater impact on potential remediation equipment, etc. Total solids required for QA/QC purposes for soil samples (see QAPP).

6: Only if results of soil vapor survey show the presence of volatile organic vapors at a concentration greater than 1 mg/l (see FSAP OU-1).

of VOC contaminant concentrations to date. MW-12 will also be approximately 450 feet south of existing deep multi-port well MW-11 (Figure 6-1).

When completed, MW-12 will extend to crystalline bedrock (estimated to be approximately 750 feet below grade), have five screened intervals and be used to monitor contaminant movement off the JPL site during normal groundwater flow conditions (to the southeast). In addition, well MW-12 will potentially evaluate any contributions Seepage Pit Nos. 8, 9, 13, and 13A may or may not have made to the groundwater. These seepage pits are currently located underneath Building 302 and are inaccessible to direct soil sampling (see OU-2 FSAP). As a deep multi-port completion, the well will also be used to provide further information on the vertical contaminant distribution previously identified in nearby deep multi-port wells MW-3 and MW-11 as well as further evaluate the vertical groundwater flow component beneath the site for modeling purposes. MW-12 will also serve as a control point for potentiometric-surface surveys which will be used to further define the dynamic groundwater table in the eastern section of the site. The groundwater table here can be significantly affected by the Arroyo Seco spreading grounds and the nearby City of Pasadena municipal production wells.

- **Rationale for Well MW-13**

Well MW-13, a proposed 4-inch-diameter shallow monitoring well, will be located south of the southeastern corner of Building 111, along Sergeant Road (Figure 6-1). The well location, under normal groundwater flow conditions (to the southeast), is downgradient of historic Seepage Pits Nos. 23, 24, and 25 (Figure 6-1). These seepage pits have a varied waste history, including being the only location where there was possible disposal of low-level radioactive wastes. The constituents of interest to be monitored in this well will therefore also include gross alpha and gross beta radioactivity. MW-13 will extend to an estimated depth of 250 feet below grade and will be used to monitor the groundwater downgradient from these seepage pits and provide a control point for potentiometric-surface information. During periods of high precipitation, when the groundwater flow direction reverses, well MW-13 will also be used to monitor the groundwater downgradient of the northeast section of the site.

- **Rationale for Well MW-14**

Well MW-14, a proposed 4-inch-diameter, deep multi-port well, will be located adjacent to existing well MW-2, in the extreme southwest corner of the site. This

well is intended to essentially replace well MW-2, which was completed above the water table (Geotechnical Consultants, Inc., 1989) and has not been considered a monitoring well.

MW-14 will extend to crystalline basement rocks (estimated to be 650 to 700 feet below grade), contain five screened intervals, and will serve to provide data concerning possible transport of contaminants from upgradient off-site sources during normal groundwater flow conditions (to the southeast). During periods of high precipitation, when the groundwater flow direction reverses across the site, MW-14 will be used to monitor the groundwater at the downgradient edge of the site. Data regarding contaminant types, concentrations, durations of various groundwater flow directions, data from off-site upgradient sources, etc., will be carefully evaluated to potentially determine where contaminants, if present, originated from, either off-site or on-site sources. Well MW-14 will also provide additional data for evaluating the groundwater table elevation as well as the vertical groundwater flow component beneath the western-most edge of the site for modeling purposes. As a deep multi-port completion, vertical and horizontal contaminant distribution will be monitored.

- **Rationale for Well MW-15**

Well MW-15, a proposed 4-inch-diameter shallow monitoring well, will be located southwest of Building 121, near several seepage pits on the eastern border of the site (Figure 6-1), and extend to an estimated depth of 80 feet below grade. MW-15 will serve monitoring purposes along the site's eastern border and will provide potentiometric surface elevation data that will contribute to better understanding the dynamic hydrology for that section of the site.

The water levels in well MW-1, near the mouth of the Arroyo Seco canyon, have always been historically higher than those measured in the other wells on the site and have not fluctuated nearly as much as those measured in the other wells on the site (± 30 feet). This may be related to the proximity of well MW-1 to the mouth of the Arroyo Seco canyon, the uplifted crystalline basement rock at the mouth of the canyon (related to the JPL Thrust Fault) and to the point of groundwater recharge related to the mouth of the canyon. For this reason, it is anticipated that the water table at the proposed location of well MW-15 will be relatively stable and shallow compared to the rest of the site. Therefore, well MW-15 will be installed to a shallower depth relative to the rest of the proposed wells on the site.

- **Rationale for Well MW-16**

Well MW-16, a proposed 4-inch-diameter shallow monitoring well, will be located approximately 175 feet southeast of Building 248 (Figure 6-1) and extend to an estimated depth of 300 feet below grade. This location is about 500 feet west (upgradient during normal groundwater conditions) of existing shallow well MW-7 and immediately east (downgradient during normal groundwater conditions) of an area southeast of Building 248 where solvents were reportedly disposed of into three shallow unlined pits (area reference number WP-3 used in OU-2 FSAP) over a short period of time (Figure 6-1).

MW-16 will serve to characterize the upgradient (during normal groundwater flow conditions) extent of contaminants previously identified in well MW-7 and assist in determining if the reported disposal of solvents southeast of Building 248 have impacted groundwater. During periods of high precipitation, when the groundwater flow direction reverses, well MW-16 will potentially monitor the groundwater downgradient of well MW-7. MW-16 may also provide a control point for potentiometric-surface information north of the JPL Thrust Fault (Figure 6-1), if it is determined MW-16 is located north of the fault. If MW-16 is north of the fault, a second well will be installed, if determined necessary, south of the fault and upgradient of well MW-7 during the latter part of the RI.

As part of the RI, the wells at JPL will be sampled, at a minimum, during the dry season and the wet season of the year. To accomplish this with the current schedule, the currently existing wells are proposed to be sampled in October 1993 as part of a dry season sampling event. It is anticipated that the proposed wells can be installed, developed, and ready for sampling sometime in late winter. Groundwater samples will then be collected from all JPL monitoring wells shortly after all new wells are installed, representing a wet season sampling event. Additional sampling may be proposed during the latter stages of the RI (\pm May, 1994) based on the new well information and the contaminant concentration history of the existing wells. If additional wells are installed during the latter stages of the RI, they will be sampled during the latter stages of the RI. The regulatory agencies (EPA, DTSC, and RWQCB) will be involved in any decision made to stop monitoring a well. NASA's Designated Project Manager (NDPM) will notify all regulatory agency's Project Managers not less than 10 days in advance of any sampling event as required in Section 22.2 of the FFA. Groundwater samples will be analyzed for volatile organic compounds, semi-volatile organic compounds, Title 26 metals with hexavalent chromium (plus strontium), cyanide, and major cations and major anions. In addition, groundwater samples from proposed well MW-13 will also be analyzed for radioactivity (gross alpha and gross beta), and samples from existing well MW-4 will also be

analyzed for total petroleum hydrocarbons (TPH) because of the close proximity of well MW-4 to Building 306 where previous excavations for the building's foundation encountered soil contaminated with TPH (see Section 5.1.13). The major anion and cation data obtained during the RI groundwater sampling events, coupled with hydrologic observations, will potentially be useful for (1) interpreting groundwater flow patterns and contaminant migration, (2) evaluating the possible effect of surface-water runoff on groundwater quality, (3) evaluating the possible contribution of contaminants from seepage pits, and (4) evaluating the effect of inorganic constituents on the performance of potential remediation equipment. In addition, soil samples and samples of soil cuttings will be collected during the installation of the proposed wells. Relatively undisturbed soil samples will be collected during drilling at each well from the 10-, 20-, and 30-foot depths to help characterize the soil at the site. Samples of soil cuttings will be collected to evaluate cuttings-disposal options only (see FSAP OU-1) pursuant to EPA guidance on investigation derived waste (EPA, 1991 and 1992a). Should analyses show the soil cuttings are hazardous, disposal at an approved, licensed offsite facility will be arranged.

Reports of analytical results from groundwater samples for constituents of interest including volatile organic compounds, semi-volatile organic compounds, Title 26 metals with hexavalent chromium (plus strontium), cyanide, radioactivity (proposed well MW-13 only) and TPH (well MW-4 only) will include EPA Level IV data packages. The results from the initial sampling event, and 10 percent of all subsequent results, will be validated using approved EPA guidelines as described in the QAPP as a check on laboratory performance. Reports of analytical results from the laboratory for general water chemistry analyses (major anions and cations) (not constituents of interest) will be evaluated for data quality and presented with EPA Level III data packages.

A field quality assurance (QA) sampling program will also be enacted to evaluate the precision of the laboratory analyses, the effectiveness of decontaminating the sampling equipment, and sample-handling and bottle-preparation procedures. Collection of duplicate samples, equipment blanks, field blanks, and trip blanks will be included in this program as described in the FSAP for OU-1. The proposed analyses to be used on field QA samples are summarized in Table 6-2.

Water-level measurements will be collected from all JPL monitoring wells to characterize variations in the water table over time and the direction of groundwater flow beneath the site. In the shallow monitoring wells, depth to groundwater measurements will be collected with an automated water-level measurement system. This automated system consists of a pressure transducer connected by a cable to a data logger that is located in the surface completion of each shallow well as described in the FSAP for OU-1. The pressure transducer simply measures the pressure a column of water above it exerts on it. The data logger then converts the pressure

reading into feet of water and records this measurement along with the day and time of the measurement.

In the deep multi-port monitoring wells, the piezometric surface or hydraulic head at that location in the aquifer, at each sampling port is measured with a pressure-transducer probe manufactured especially for the unique casing used in these wells. These measurements are currently made on a quarterly basis coinciding with quarterly sampling events and will be continued during each subsequent RI sampling event.

In addition to monitoring groundwater flow directions and gradients as part of the characterization of the aquifer at JPL, tests on the aquifer will be performed in each shallow monitoring well on the site to evaluate the hydraulic conductivity of the aquifer as described in the FSAP for OU-1. The hydraulic conductivity, along with groundwater gradients, will be used to evaluate groundwater-flow rates beneath the site.

During drilling of each new well, relatively undisturbed soil samples will be collected at 10-foot intervals beginning at 10 feet below ground surface down to 30 feet (see FSAP for OU-1). Prior to drilling at each well location, a mobile soil-vapor sampling van will be used to collect one soil-vapor sample at each proposed well location from a depth of 20 feet, or shallower if refusal occurs, to evaluate whether or not soil samples will be analyzed for volatile organic compounds. Each soil vapor sample will be analyzed for volatile organic compounds in accordance with the RWQCB's guidelines (see FSAP for OU-2). The soil samples subsequently collected during drilling will be analyzed for semi-volatile organic compounds, Title 26 metals with hexavalent chromium (plus strontium), cyanide, nitrate, total solids, and total petroleum hydrocarbons (Table 6-2). At locations where the total volatile organic compound content in the soil-vapor sample exceeded 1 mg/l, the soil samples will additionally be analyzed for volatile organic compounds. The analytical results will be used to identify any potential contaminants encountered while drilling.

The shallow monitoring wells will be drilled with a percussion-hammer drilling rig that utilizes a dual-wall drive pipe and reversed-air circulation. Details are included in the FSAP for OU-1. The dual-tube percussion method of drilling can be described as a double-wall pipe driven by a pneumatic- or diesel-operated drive hammer, while filtered air is forced downward through the annulus of the double-wall drive pipe to the bit (Figure 6-8). The air returns upward through the inside pipe, bringing with it a continuous discharge of drill cuttings. The dual-tube percussion method provides accurate lithology determination, the ability to drill through deep aquifers without cross-contamination, and the capability to install a 4-inch diameter monitoring well to various depths.

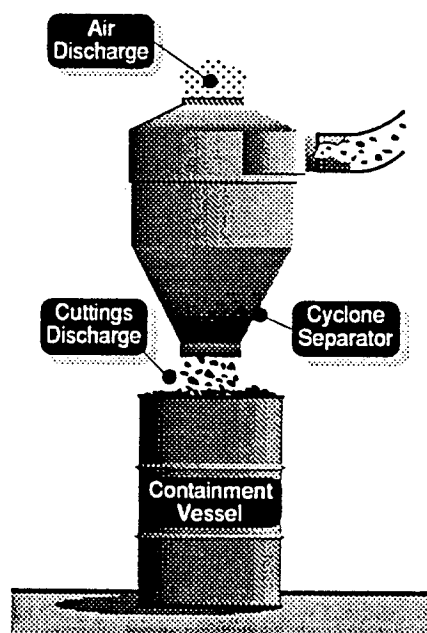
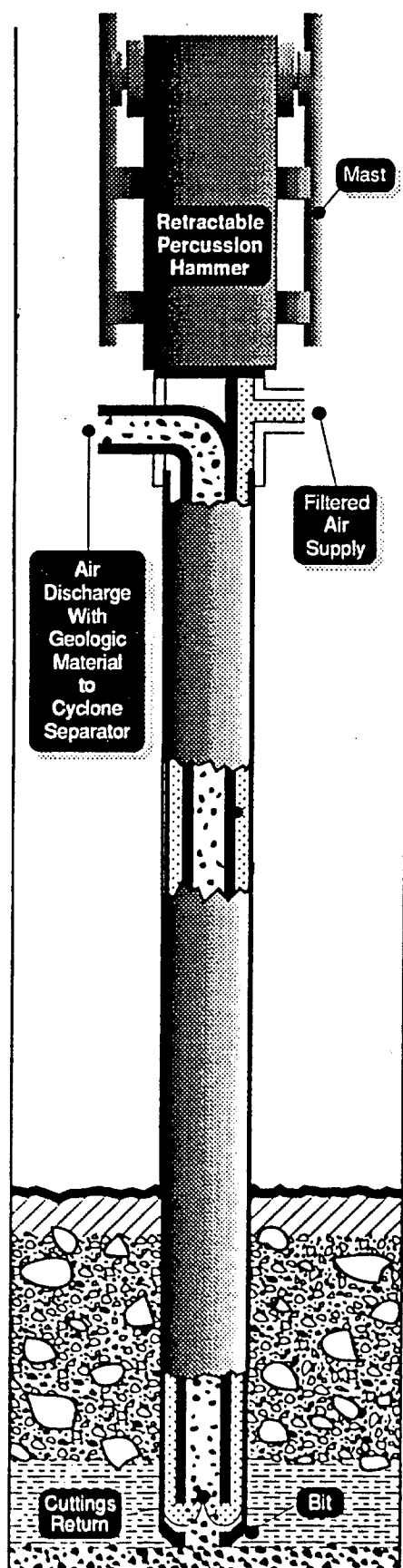


Figure 6 - 8

Generalized Drawing of
Dual-Tube Percussion
Method of Drilling

A typical design for the shallow monitoring wells is shown in Figure 6-9. Each shallow monitoring well will contain 50 feet of screen. The purpose of this design is to allow for the sampling of contaminants at the water table surface and to obtain water level information from a water table that can fluctuate significantly. The screen length was selected because of the large fluctuation in water table elevations observed in the wells on the site resulting from intermittent pumping of the nearby City of Pasadena municipal water production wells and seasonal recharge from the nearby Arroyo Seco spreading grounds. A history of water elevations recorded at JPL since 1990 showing a change in water levels up to approximately 90 feet (except in well MW-1, which is near the mouth of the Arroyo Seco Canyon where water levels fluctuated approximately 30 feet) is included on Figure 4-17 in Section 4.2.5.

During the nearly 3 years of groundwater elevation monitoring at JPL, there has been a large shift in static water levels in the wells monitored. During those 3 years, the Pasadena area has experienced a significant drought (1986-1991) along with a very prolific rainy season (1993). These events have resulted in water table fluctuations that are not normally expected for this area. As a result of these two significant events, the water table has fluctuated a total of close to 90 feet, except in well MW-1, where water levels have fluctuated close to 30 feet. The likelihood of such large fluctuations occurring again is low and that an average fluctuation of around 30 to 40 feet is more likely to occur. A history of precipitation recorded from a rain gauge located adjacent to JPL (at the Pasadena Chlorine Plant located in the Arroyo Seco just east of well MW-9) beginning in the year 1916 is presented in Figure 6-10. Review of Figure 6-10 suggests periods of above normal, or above average, precipitation typically last 1 to 2 years, and are followed by periods of below average precipitation. As shown on Figure 6-10, the rainy seasons for 1992 and 1993 were both above average in terms of amount of rainfall, and one may expect that the next few years may have normal, or below normal, amounts of precipitation. Therefore, the amount of seasonal water level fluctuation may not be as high as previously recorded.

It is anticipated that a screen length of 50 feet would likely allow continuous sampling of the water table during the duration of the OU-1 RI. The location of the well screen in each well will be chosen based the historical water elevations recorded at JPL and not necessarily on the water table encountered during drilling. Well screens will be located approximately between the elevations of 995 and 945 feet above sea level, except for well MW-15, which is located near the mouth of the Arroyo Seco Canyon and well MW-1 (Figure 4-17). The screen in well MW-15 will be located at a higher elevation (approximately 1,000 to 1,050 feet above sea level) based on historical water elevation data obtained from nearby well MW-1 (Figure 4-17). The well screens will be installed at their proposed elevations based on ground surface elevations obtained from topographic maps of the site with 2-foot contour intervals. After waiting 48 to

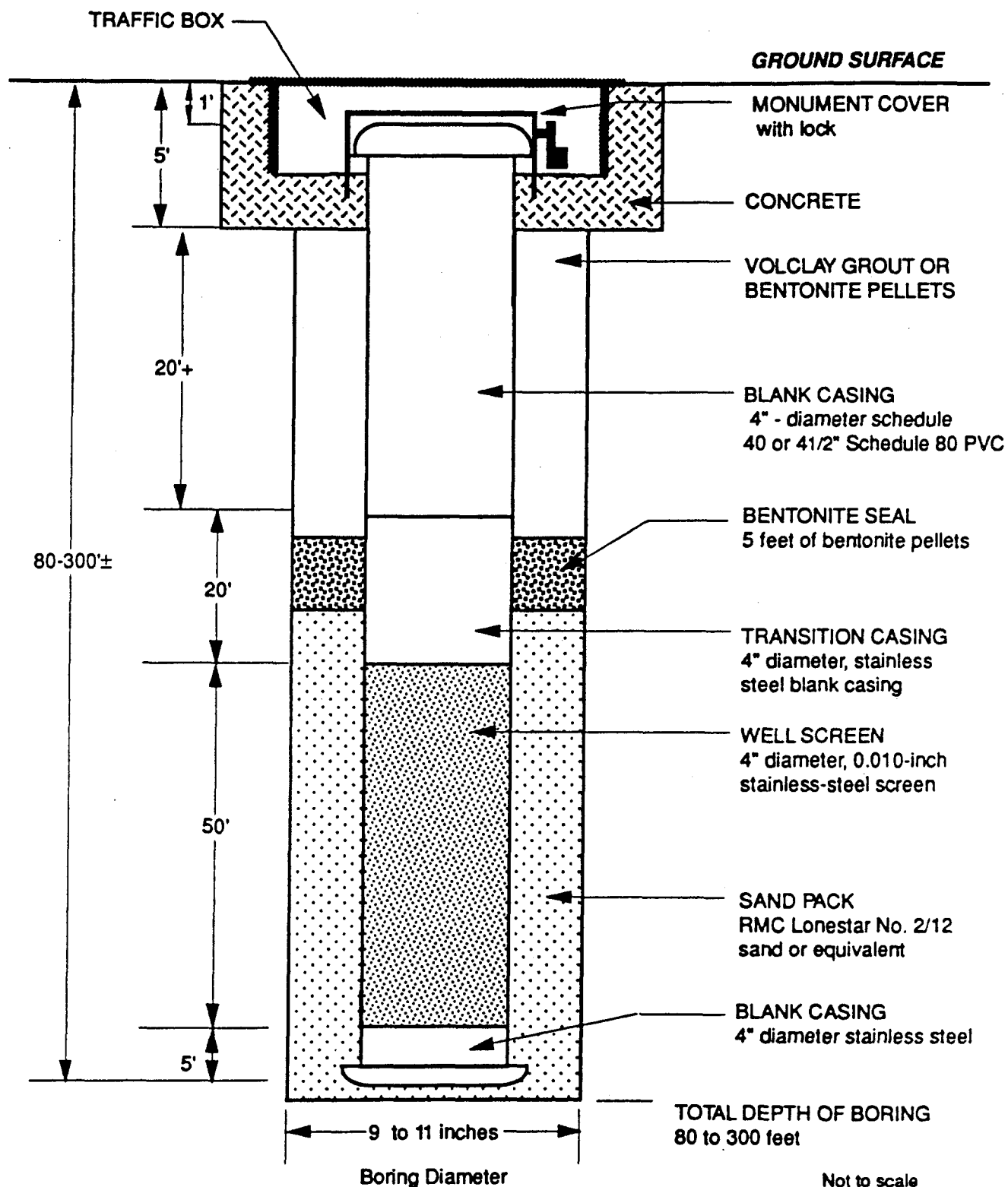
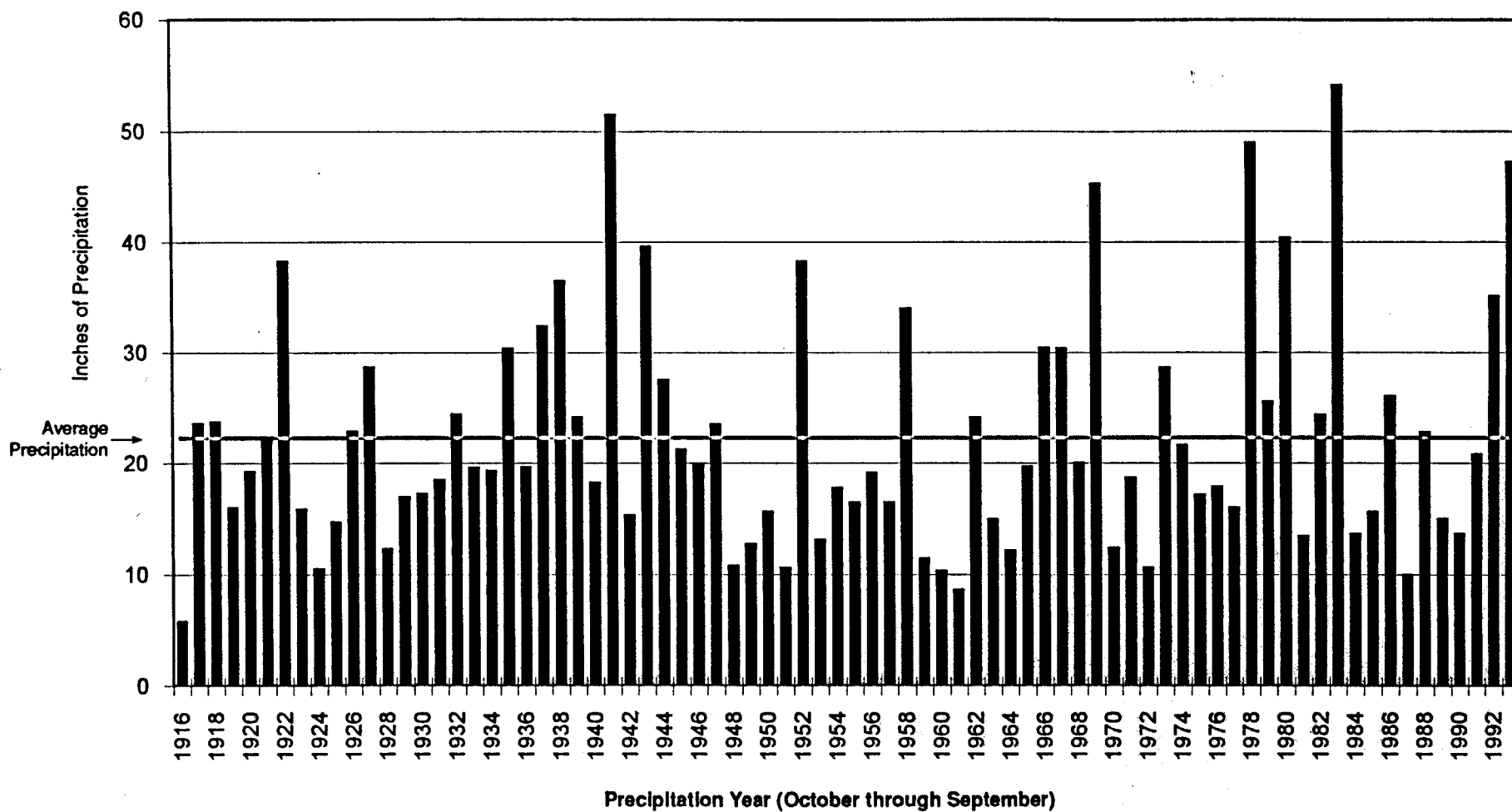


Figure 6 - 9

Design of Typical Shallow
Groundwater Monitoring Well



(Data from rain gauge at Pasadena Chlorine Plant Located in the Arroyo Seco East of Well MW-9)

Figure 6 - 10

**Yearly Precipitation Data Near
Jet Propulsion Laboratory**

72 hours after well installation, to allow enough time for the grouting materials to cure, each well will be developed to remove all fine materials surrounding the well casing and to stabilize the filter-pack material (see FSAP for OU-1).

The deep multi-port (MP) monitoring wells have been designed to sample the aquifer at five separate depths using a single casing. Three similar systems have previously been installed on the site (MW-3, MW-4, MW-11) using casing components manufactured by Westbay Instruments Ltd.. During this RI, two additional deep multi-port wells will be constructed in the same manner using a mud-rotary drilling rig. Details of well drilling and installation procedures for the 4-inch-diameter casing are included in the FSAP for OU-1. A typical design for the deep monitoring wells is shown in Figure 6-11. After the 4-inch casing is installed, each of the five screened intervals in the wells will be developed. After this initial development, as described in the FSAP for OU-1, the multi-port casing system will be installed. The MP casing system consists of various components including 1.5-inch-diameter schedule 80 PVC blank casing, PVC couplings used to connect various casing components, PVC measurement-port couplings that facilitate pressure measurements and water sampling, PVC pumping-port couplings that allow well purging or hydraulic-conductivity testing of the aquifer, and nitrile rubber inflatable packers that seal the annulus between screened zones. Once the MP casing has been placed in each well, the nitrile rubber packers between screen intervals will be inflated. After installation, several additional QA/QC checks will be performed. The operation and detailed descriptions of the equipment and procedures used during MP casing installation and procedures for the required QA/QC checks are included in the FSAP for OU-1.

After installation of the MP casing system, each screened interval will be developed further. Each screened interval will be developed by opening the pumping-port valve at that screen and purging water from the screen interval (see FSAP for OU-1). Each screen interval will be considered developed when the pH, conductivity, turbidity and temperature measurements reach stability and at least three well volumes of the screened interval water has been produced.

At JPL, groundwater samples are currently being collected on a periodic basis from each of the existing monitoring wells. All shallow wells are sampled with a 2-inch-diameter Grundfos Redi-flo2® submersible pump. This method of sampling is recommended by EPA in "RCRA Groundwater Monitoring: Draft Technical Guidance" (EPA 1992c), which updates technical information contained in EPA's Technical Enforcement Guidance Document (TEGD). The necessary equipment and procedures for the collection of groundwater samples from the existing and proposed wells are presented in the FSAP for OU-1.